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CONCERNING SYSTEMATIC EXPOSITION OF MATHEMATICS AND THE FUSION OF ITS VARIOUS BRANCHES IN SECONDARY INSTRUCTION.[1]

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I shall consider the proposed questions in part from the point of view of their mathematical subject-matter and the age of the pupil, without regard to the limitations of any particular national environment or educational organization, and in part from the point of view of American local conditions. Preparatory to the latter, it is necessary to point out very briefly certain features of the American organization that must be taken into account in considering whether or not the lines of treatment that are brought forward in the questions are practicable under American conditions.

The nine years that a German or a French boy spends in a single institution (*gymnasium, lyçée*) under the same corps of teachers, all mathematically prepared to do the most advanced work in the curriculum, all working together consistently toward the same goal, are in America covered in three different types of institutions, with different aims, different organization, different methods, and with different teachers of quite different degrees of mathematical attainment.

Five years (normal minimum entrance ages, 9-13, inclusive) are passed in the elementary schools. Here the pupil is taught arithmetic (*Rechnen, Calcul*) with some observational *geometry* and mensuration of geometric figures, by a teacher (almost in-

[1]Discussion of the questions referred to Subcommission A of the International Commission on the Teaching of Mathematics for report at the session at Milan, Italy, September 18-21, 1911. The questions in full read as follows:

I. To what extent can the work of secondary schools take account of systematic exposition of mathematics?
(*a*) In geometry; use of axioms.
(*b*) In arithmetic and algebra.
(*c*) In the subsequent mathematical instruction.

II. The question of the fusion of the different branches of mathematics in secondary instruction.
(*a*) Algebra and geometry.
(*b*) Plane and solid geometry.
(*c*) Plane geometry and trigonometry.
(*d*) Solid geometry and descriptive geometry.
(*e*) Synthetic and analytic geometry of the conic sections.
(*f*) Differential and integral calculus.

variably a woman) whose mathematical training has seldom extended beyond a year each of elementary algebra and geometry and often not that far. This one teacher teaches the pupil in all subjects and has no special aptitude or training for teaching arithmetic rather than English, history, geography, etc.

Three years (normal minimum entrance ages, 14-16, inclusive) are passed in the "high school." Here the pupil is taught elementary algebra (through quadratics) and plane and solid geometry by a teacher (in probably the majority of cases a woman) whose mathematical training has with rare exceptions not extended beyond a year's course in the calculus and in the majority of cases not that far. The teaching of mathematics is usually done by a special teacher of that subject or of mathematics and some other subject, for example, physics, though isolated classes in mathematics are often allotted to teachers whose specialties are subjects quite unrelated to mathematics.

One year (minimum entrance age 18 years[2]) is spent in college. Here the student is taught additional algebra, trigonometry, the elements of analytic geometry and sometimes of the calculus by an instructor (almost invariably a man except in the colleges for women), who in the better institutions often holds the doctor's degree in mathematics.

It is apparent from this brief sketch that the questions whether any proposed change is desirable in theory and whether it is feasible in practice may, under American conditions, receive quite different answers.

I. The Influence of Systematic Exposition of Mathematics on Secondary Instruction.

Question I. *To what extent can the work of secondary schools take account of systematic exposition of mathematics?*

I state first upon what interpretation of the terms of the question my reply is based. By "secondary school" I understand the nine years mentioned above. By "systematic exposition of mathematics" I understand its formal presentation so as to put its logical organization into the foreground, and so as to present in due sequence a complete chain of definitions, axioms, and theorems. And finally, I understand "take account of" (*tenir compte*) broadly as meaning not merely the actual "systematic

[2]The high school course covers four years but no mathematics is ordinarily taken up by the pupil in the fourth year.

exposition" in the secondary class room of fields or topics of mathematics, but also the indirect influence which such expositions elsewhere within the teacher's experience, *e. g.*, in university lectures and in publications, may have on secondary instruction.

In the latter sense, the work of the secondary school can and should take full account of the systematic exposition of mathematics. As a part of his academic preparation, the teacher should have mastered not only the systematic exposition of numerous fields of higher mathematics, but also the systematic and critical exposition of the entire field covered by the secondary curriculum, together with relevant topics of higher mathematics. The former has always been amply provided by the universities and it is most gratifying to note that courses of the latter character are also beginning to be offered in various universities. May their number rapidly increase! The great majority of university students of mathematics (in America at least) will later teach in the secondary field as defined above to include the freshman year in college, and will be greatly benefited by a systematic exposition of the logical structure of the various fields of secondary mathematics presented with the broad outlook and expert insight of the university mathematician. I am here thinking, of course, of the theory itself, without regard to methodic or didactic questions, though I am of opinion that the university might well occupy itself with such questions also, at least incidentally.

When once the teacher is actually at work, he should keep in touch with the progress of systematic thought in his field. Here likewise the universities can be decidedly helpful both by suitable courses of instruction given at times when the secondary teacher is free to attend and by publications aiming to keep abreast of the thought of the day.[3]

Granted then that the teacher himself is well acquainted with a thorough and up-to-date systematic exposition of the subjects that he teaches, we pass to the question of how this knowledge should affect his instruction.

It goes without saying that the instruction which he gives should be consciously built up on a logical system, a well-articulated skeleton bearing the mathematical organism; but it does not follow that the pupil should be any more conscious of this skeleton supporting the body of mathematical doctrine in the

[3]Introductions to nine important domains may be found in: Monographs on Topics of Modern Mathematics Relevant to the Elementary Field. New York, Longmans, Green & Co. 1911.

secondary class room, than he is of the skeleton supporting the body of the teacher himself. Young people may easily be frightened if a skeleton is prematurely dangled before them. Systematic organization is a relatively late event in scientific development. First, the concrete facts are acquired. Then the body of doctrine in the form of more or less isolated theorems is abstracted from them. Finally, the body of abstract knowledge is organized into a systematic whole.

Accordingly, it would seem that in the secondary course as a whole, as well as in the work of any particular year or the exposition of any particular topic, the beginnings should be concrete; abstract treatments (abstract relatively to the maturity and degree of advancement of the pupil) coming as a relief from the burden of carrying through many essentially like concrete instances. This presents as goal for the class room: not abstract mathematics but mathematics that is then and there *abstracted*. It has well been pointed out by Herbert Spencer[4] that "general formulas which man have devised to express groups of details, and which have severally simplified their conceptions by writing many facts into one fact, they have supposed must simplify the conceptions of a child also. They have forgotten that a generalization is simple only in comparison with the whole mass of particular truths it comprehends, that it is more complex than any of these truths taken singly . . . and that to a mind not possessing these single truths it is a mystery. Thus confounding two kinds of simplification, teachers have constantly erred by setting out with 'first principles.'"

From the point of view of the pupil, systematic organization is rather the crowning product than the foundation stone of the exposition, and as he progresses through the advancing years of the curriculum, his increasing measure of maturity and his enlarging fund of mathematical knowledge furnish better and better basis for the formal organization of this stock of facts into a coherent system.

We should perhaps also consider the question briefly under the much narrower interpretation of systematic exposition as an exposition from which intuition is rigorously excluded, and the whole body of doctrine is built upon a set of definitions and postulates explicitly formulated.

So far as secondary instruction is concerned it seems to me very unwise to attempt to exclude intuition from it at any stage,

[4]Education, Chapter 2.

or to restrict or to hamper in any way the freedom of appeal to intuition. The nonintuitional researches of recent decades have, indeed, an important bearing upon secondary instruction and accordingly the teacher should be acquainted with their general results, and should have gone with them with sufficient detail to have comprehended their spirit.[5] But this bearing is not of the nature of pressure for less appeal to intuition in the class room and for more explicit striving after formal rigor, but quite the reverse. The teacher needs only to examine a set of consistent and independent postulates for plane geometry, for example, to see how utterly impracticable they are for the class room. He will find axioms stated and theorems proved that have hitherto tacitly been taken for granted in the class room and that are intuitionally so obvious that any mention of them would only confuse the pupil. For example:

The undefined terms are "point" and "order."

Axiom I.—There exists at least two distinct points.

Axiom II.—If points A, B, C, are in the order ABC, they are in the order CBA.

Axiom III.—If points A, B, C, are in the order ABC, they are not in the order BCA.

Theorem 1.—If the points A, B, C, are in the order ABC, they are not in the order CAB. (Proved by axioms II and III).

Theorem 2.—The order ABC implies A is distinct from B, and B from C.

Later theorems:

Theorem 5.—If DE is any line, there exists a point F not lying in this line.

Theorem 6.—Between every two distinct points there lies a third point.

These axioms and theorems are cited to show how few and simple are the statements from which alone all the others can be proved, and how futile is the campaign that is being waged, even to this day, against "taking nothing for granted that can be proved." They make it clear that it is not practicable to enumerate in elementary geometry all the axioms there used, nor can those used be restricted to such as are indemonstrable by means of the others. No proof even of the consistency of those used can be attempted. It is sufficient that they are valid in the concrete geometry of the world about us; and such special verification, by the way, is the mode of proof used by writers on the subject in establishing the consistency and the independence of their axioms. The recent researches on axioms explode, once for all, the hope of

[5]An excellent presentation of modern views on the foundations of geometry and algebra is given in the monographs by Veblen and Huntington in Monographs on Topics of Modern Mathematics Relevant to the Elementary Field, New York, Longmans, Green and Co., 1911.

teaching the child a geometry in which all the results are rigorously deduced from a set of irreducible first principles, and with it goes the only justification for any longer professing to be teaching such a rigorous deductive system.

The teacher who reads these researches aright, will give free play to intuition, accepting without proof anything that is intuitionally sufficiently obvious; he will tacitly assume some of his fundamental postulates or axioms, others he will state informally preceded by an "of course," or "it is evident that," while he will perhaps present still others in a formal manner as "axioms." He will begin with theorems sufficiently complicated to require proof in the eyes of the pupil, he will vary at will from traditional forms, will make free use of motion (superposition, parallel translation, rotation about a point or an axis), in definition or in proof, whenever he feels that such use will simplify matters, and in all this he will be undismayed by the knowledge that his system will be egregiously redundant, but will be satisfied by the knowledge that the proofs which are professedly given are real proofs both in the sense of being legitimate consequences of the body of assumptions that is used, and also in the sense of convincing the pupil of the correctness of statements not otherwise obvious to him.

Passing to the subquestions, it does not seem necessary to add anything further in reply to subquestions a, b, c. As to question d, I would say that, so far as America is concerned, the teachers except those giving the collegiate instruction, have themselves but scant acquaintance with the modern developments of mathematics, and accordingly these ideas have not yet made any marked impress upon the secondary instruction of the country as a whole. There exists, however, a large and growing body of teachers, who are availing themselves of the facilities offered by the summer sessions of universities and colleges, by the meetings of various associations of teachers, and by books and periodical publications, to enlarge their fund of mathematical knowledge and to come into touch with modern ideas.

Mention may also be made here of two proposals which, while not relating to strictly modern developments of mathematics, have been prominent in recent discussions and have formed widespread acceptance. One is to pay more attention to the applications of mathematics in the physical sciences and in practical life, and the other is to give more prominence to the function concept (in-

cluding the graphic representation of functions on squared paper).

II. THE QUESTION OF THE FUSION OF THE DIFFERENT BRANCHES OF MATHEMATICS IN SECONDARY INSTRUCTION.

This question can be discussed best under the various sub-questions.

(*a*) *Algebra and geometry.* In America, the practice as to the teaching of these subjects has been and still is the opposite extreme of fusion. The subjects are taught in separate years, and when one is taken up the other is completely laid aside. Algebra is usually begun in the first year of high school (the sixth year of the nine year period styled "secondary" above) and is taught during the whole of that year. In the next year, plane geometry is usually begun and completed. No use is made of the algebraic knowledge acquired in the previous year. In the following year, algebra is again taken up for one-half year, and solid geometry is begun and completed in the other half year. The course in algebra ignores the pupil's knowledge of plane geometry and the course in solid geometry, in return, ignores his knowledge of algebra. Within the last decade or so, a few institutions have varied from the above plan and have given trial to various plans of fusing the work in algebra and geometry of the two first years of the high school (the sixth and the seventh year of the "secondary" period) into a single coherent course in "mathematics." This work is still in the experimental stage and it is too early to speak of its probable outcome.

The simultaneous teaching of algebra and geometry, in lieu of their successive teaching, has also been proposed, but has hitherto been undertaken by an exceedingly small number of institutions. The juxtaposition of the two subjects is readily feasible under existent conditions[6] and would make attainable most of the desirable features of fusion, without requiring the thorough reorganization of the work which the latter demands. This plan calls for a more or less nearly equal division of time between the two subjects annually, but by no means requires that the time of each week or month be so divided.

Personally, I believe firmly in the simultaneous teaching of algebra and geometry rather than in the tandem teaching of these subjects that is in vogue in America. The experience of the world as a whole amply justifies this belief and I need not argue the question here. Such simultaneous teaching offers the

possibility of considerable use of the methods of each subject in the treatment of the problems of the other, and pains should be taken, especially in America, to utilize these possibilities. I should like to see the two subjects taught as coördinated, mutually helpful fields of mathematics, and believe that the impenetrable wall that has so long separated them in America should be torn down or pierced with an abundance of doors, making it possible to pass from one field to the other at will. But the removal of the wall will not alter the essential character of the fields. If one was a plain, the other a hillside, they will remain as they were after the wall is torn down.

It seems to me that the fields of algebra and geometry are essentially different, both in ground covered, and in method used. These differences seem sufficient to preclude the possibility of fusion of the two into a homogeneous whole that shall be neither algebra nor geometry, but a real composite of the two. And it would impress me as a distinct loss, if anyone should ever prove ingenious enough to fuse into a neutral-tinted average these two fields and methods of thought each so vivid and well marked. I wish my roast beef and sweet coördinated in a single dinner, but I do not wish them fused into a single dish.

(b) Plane and Solid Geometry; (c) Plane Geometry and Trigonometry; (d) Solid Geometry and Descriptive Geometry. I have not given sufficient attention to the question of the fusion of these pairs of subjects, to say much of value. So far as I know, these cases of fusion have not been attempted or seriously considered in America, and whatever their theoretic merits, the time is not as yet ripe for their introduction in this country. For an American the questions of the desirability of the fusion of these branches is to-day entirely an abstract one, and thus its consideration is likely to be crowded out by that of other changes which could more readily be undertaken now if found desirable. In the abstract, and on the basis of very casual consideration, I am by no means convinced that it would be desirable to fuse these subjects in the first courses therein.

It would, however, seem to be an excellent plan to group together in the course in solid geometry, various sets of analogous theorems from plane and solid geometry. This might be done towards the close of the course in solid geometry, and in connection with a summary and review of both subjects.

[6] In the general absence of central legislation, it is possible in the great majority of instances, for simple schools on local systems independently to make a change of this sort whenever they wish to do so.

It may perhaps be worth while to define the trigonometric functions for acute angles in connection with the study of similar right triangles, and to introduce and use tables of the natural values of these functions in the solution of right triangles. The definitions may then be extended to obtuse angles, and the formulas necessary for the solution of oblique triangles proved geometrically and used in the solution of simple problems. When algebra and geometry are taught simultaneously, logarithms may be taken up in the algebraic work shortly before the trigonometric functions are studied, thus making possible the use of logarithmic tables also. While this measure of study of the trigonometric functions seems promising as a part of plane geometry, I feel by no means sanguine about the early introduction of the more general portions of the subject, such as the definition of positive and negative angles of any magnitude and of the trigonometric functions of such angles, the general proof of the relations between the functions of x and of angles of the type $\frac{n\pi}{2} \pm x$, the addition formulas and their consequences, and the like. It would seem safer to reserve this portion of what is ordinarily given under the head "trigonometry" for the closing year or so, of the secondary period, that is, for the freshman year in college or possibly under favorable circumstances, the fourth year of the high school.

(*c*) *Synthetic and Analytic Geometry of the Conic Sections.* No attempt has been made in America, to my knowledge, to fuse these two modes of treatment. The consensus of opinion seems to be that the development of the new and important method of analytic geometry is of the first consequence and that it would be hampered rather than aided by treating the problems taken up by the synthetic methods which are already familiar to the student. The American student of analytic geometry is seldom under eighteen years of age and often over twenty, and has sufficiently well-developed powers of attention and concentration to follow to advantage a prolonged development by the analytic method only. It is, however, well worth while considering whether a collegiate course in synthetic geometry of some sort, quite possibly of the conic sections, might not well be introduced in America. At present, the high school work in algebra is continued in college by college algebra, the theory of equations and the like, but there is no corresponding continuation of the work in elementary synthetic geometry. Hence the stu-

dent's algebraic knowledge is increased and his algebraic horizon widened by his collegiate work, but his knowledge of elementary synthetic geometry is not directly increased at all. Even after considerable study of mathematics when he goes out from college or university, he finds himself facing his class in geometry as teacher with only that knowledge of the subject which he obtained in a similar class as pupil.

(*f*) *The Differential and the Integral Calculus.* The fusion of these two subjects to various extents has been tried in America without, so far as I know, any decisive outcome. I take it that few favor the closest possible measure of fusion, that is, the definition at the outset of the three fundamental concepts of the calculus—the derivatives, the indefinite integral, and the definite integral—and the immediate treatment of every problem as far as feasible from each of these points of view. On the other hand, few would favor the other extreme, of a prolonged and detailed course in the differential calculus before ever the elements of integral calculus are introduced. After experimenting with various possibilities my own present practice is first to carry the work in differential calculus to the extent of covering the differentiation of the usual functions and their combinations by the usual operations, the successive derivatives of simple instances of such functions, curve tracing (use of first and second derivative), maxima and minima, simple treatment of Maclaurin's and Taylor's series with easy applications. This is followed by a very elementary study of the indefinite integral, which in turn is followed by a brief treatment of the definite integral. The degree of maturity of the American student of the calculus is such that this treatment of the inverse problem stands in sufficiently close juxtaposition with the direct problem to permit the full utilization of their mutual interrelations while his adult mind is not distracted by frequent dropping and resuming of unfinished topics, but is satisfied by the treatment of each topic with a certain degree of completeness. I have found this distribution of the subject-matter on the whole more satisfactory than the closer fusions which I have tried. It is a simultaneous teaching of the two in a single course, but not properly a fusion.

THE TEACHING OF ARITHMETIC.

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Years of teaching both in high school and college, as well as observation of school children in various grades, have convinced the writer that in the light of the results attained there is good ground for much of the criticism of present-day school methods. It is the purpose of the writer to offer some criticisms on these methods, to point out certain faults, and to make a few suggestions that seem warranted, hoping thus to express some perhaps old ideas in a form that may seem new and carry conviction because of their new dress.

The dominant question in our restless American life is how to get the greatest returns with the least outlay of time and effort. Business men everywhere are complaining that the schools are not practical, that the pupils know nothing definitely when they leave the high school, and that they are unable to make any application of their knowledge to everyday life. The question then in the public school world is, Can we not attain a greater efficiency in mental training in less time? The average pupil may be expected to give a certain amount of time and energy to his school work, but we need not expect to change materially the character of school children in this respect by the adoption of any new pedagogic principles.

On account of the importance of arithmetic in education with its universal application to everyday life, this article will refer entirely to that subject, although much of what is said along this line may apply equally well to other branches.

The fault at present in the results attained in the study of arithmetic is that the pupils have not grasped the fundamentals. Since no one can tell what are the fundamentals in a subject until he has mastered it together with its more advanced applications in allied subjects, it is, in general, the teacher who must determine what are the essentials that shall be taught. Some of the reasons for the failure of the pupils to grasp fundamentals I will try to point out in detail.

Sometimes the teacher cannot teach, or more often does not know enough "around" the subject to say himself what is fundamental and what is only bric-a-brac; again the text may not be logical and the student is swamped in work for which he is unprepared; again, the principles are concealed in a haze of petty

details or methods of solution, the result being that the pupil is so puzzled and worried over the "method" to be used that he never suspects an underlying simple principle, the understanding of which would make solution self-evident. If the principles were clear the student, instead of learning a solution, would simply know it.

I do not maintain that the texts do not contain the essentials, nor that the teachers do not, in the course of the work, cover them. What is wrong is this: the teacher does not present the essentials of the subject in such a way to the pupils that they recognize them as such.

Arithmetic owes its important position in the school curriculum to two reasons. First, it teaches certain fundamental facts and processes which everyone must use; secondly, it offers a mental drill that is more complete, more definite, and more insistent than any other branch taught in the secondary schools. If this mental discipline is to be of any effect arithmetic must be so taught as to compel this logical mental drill, and this will be attained not by a great number of memorized processes or different methods of solution, but by a few clearly cut principles, mastered and then applied to largely obvious solutions. Arithmetic rightly taught counteracts the tendency to memorize or to use certain solutions "because the book says so," and it is more true in this than in any other subject.

Let us examine a modern arithmetic, one actually in use and in the hands of thousands of children. For the purpose of illustration let us take the subject of simple interest. Here interest is treated from the simple standpoint of money paid for the use of money at so much per dollar for the period of a year, and at a proportional rate for fractions of a year. This is the fundamental principle and is treated by aliquot parts by the pupil as a matter of common sense. Now to stop here would be too easy, so next is given the six per cent method, then exact interest, then more applications of the six per cent method, for computing interest at four per cent, etc.; then exact interest, using the principles of cancellation; then interest with the use of banker's tables. I have taken exactly what is given in the particular text I have at hand. Now, anyone who knows practical life knows that there are just two systems in actual use, the first a standard method used ordinarily by everyone, and the other the interest tables followed in the banks. The six per cent method has no application outside of the school-teacher's mind. It is only the

constant worker in any method of application who uses short methods. However simple the fundamentals may be the pupil is dragged with such unseemly haste from one method to another that he acquires no facility in any one of them and loses all sight of an underlying general principle. It is to be remembered that these methods are being taught to children of twelve and thirteen, on the average. It is also suggested that the teacher would learn some valuable facts if they would find out how many pupils are receiving help at home.

In order to cover the work laid out the assignments for lessons are often too long; the conscientious pupil is worried and overtaxed, the weaker one becomes discouraged and stops after a few problems because he cannot complete the full number, when on the other hand had fewer been given he might have worked to the end. To give an actual illustration of the time and patience required for working problems, I will cite the case of a teacher who gave fifteen problems, all of which she could solve in forty minutes. A child from the class, one above the average, took ten minutes to solve and copy one problem as desired by the teacher, ten minutes to each problem; in other words, it was a two and a half hour lesson.

The treatment of stocks and bonds might be of some value were the pupil old enough to understand it, but taught to mere babes it is rubbish. Life insurance principles are taught to children at an age when they never give a thought to the morrow and what is more they do not want to think of it. Fire and marine insurance are dragged in, each one as something entirely different from anything preceding, instead of treating it as a fundamental principle of percentage.

A large share of the practical applications of arithmetic are given to children at such an age that they cannot possibly grasp their meaning, and it is not their fault. They are kept constantly memorizing facts which would in a short time become a matter of common knowledge. Again the subject-matter is too advanced and the result is that the class is constantly striving to climb a stone wall without adequate equipment in the nature of clear concepts of fundamental principles.

The various methods of handling a problem should be reduced for the benefit of the student to those simple methods that follow most closely the elements of good logic. He should be taught by a cyclic method and should by the introduction of many problems through the entire work be compelled to use

principles not found at all in the article under consideration; this frequent return to previous chapters but always to one standard method will fix in mind the principles beyond question. Young pupils do not realize that in general different methods mean only methods of attack on the same thing, but they are kept so busy in memorizing that they have no time to acquire facility in operation or to reason on principles.

If the teachers will eliminate most of the different methods of doing the same thing they will find there is plenty of time to cover the work and at the same time make better workers. The limits of this paper will not permit the consideration of the art of computation but here much time may be gained by the careful teacher who adopts in the beginning correct methods and adheres to them so consistently that the pupils come to use them with speed and accuracy.

I would here suggest two helpful principles which I believe are of constant value. First, have the pupils cultivate the habit of forming an idea of what would be a rational answer, as in doing this they will usually detect errors in any proposed solutions; and second, use the principles of cancellation; from the first day its principles can be taught and understood; this alone is of more value for saving time in ordinary computation than all other devices available.

NOTES.

At the recent meeting of the Mathematics and Science Section of the Central California Teachers' Association, the following resolution received the hearty endorsement of the members present:

"Resolved that the members of the Mathematics and Science Section of the Central California Teachers' Association most heartily commend the work of the National Committee of Fifteen on geometry syllabus as a marked step in the right direction."

The twenty-fourth educational conference of secondary schools in relations with the University of Chicago was held at the University on Friday and Saturday, April 19, 20, 1912. The conference was based upon the visitation of college classes by high school teachers during the year. There were eleven departmental conferences in which the reports of these visitors were presented in detail on Friday afternoon, and all of their programs were summarized at the general meeting on Saturday morning. This is the first conference of this kind ever held, it is believed, and it was so successful that it will be repeated next year. On Friday evening there was the annual prize contest in public speaking at which one young man and one young woman won prize scholarships worth $120 each. In the afternoon also there were prize examinations in several subjects, including mathematics, German, English, Latin, etc., in each of which a scholarship of $120 was the prize.

CONSTRUCTIVE SUGGESTIONS FOR HIGH SCHOOL MATHEMATICS.[1]

By A. W. Whitney,

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There is a considerable percentage of students who seem impervious to mathematics; if they master the subject at all it is only in a mechanical way and the matter takes no deep hold upon them. There are others who have that peculiar quality of imagination that tunes the spirit so that even the slender breeze of mathematics sets it into motion. Some of those that do not understand have no minds but with others the mind resounds only when the earth itself is struck.

I suppose it is almost an axiom in the theory of teaching to-day that there must be adaptation to the student. Not all are to be forced through the same discipline and either bent into shape or cast away; that, like the competitive system, is too wasteful and modern criteria of efficiency will not tolerate it. It neglects the fact that the result is to be measured by what is assimilated, not by what is swallowed; it would measure the result in sufferings of the flesh instead of in the growth of the spirit.

Among these boys and girls from city and ranch and of every race that we find in our classes it is our duty not merely to help those that are able to understand and that will understand, however bad our teaching, but to touch the inner life of everyone. It is a privilege to help to make scholars but it is our duty to help boys and girls to discover the universe of their own minds.

The trailing clouds of glory that these youngsters bring with them cut off the light of our mathematical teaching. The fact is the young things are full of life and they are living in a very real, concrete world. The universe to them is not points and lines and symbols, but big and solid and living; and if they are to be touched they must be touched where their spirits have opened to its generous influence. This is far from the point that is touched by the thin, austere discipline of mathematics. Mathematics is at the other end of the series; it is the sublimated spirit of the universe; physics, chemistry, biology, philosophy, all must come to it as they become more perfect, as we see beneath the wrappings to the form within; but only after

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[1]A paper read at the Mathematics Section of the meeting of the California Teachers Association at Stockton, California, December 28, 1911.

millenniums of gropings of the senses has the mind gained this vantage point and claimed its supremacy. The boy physically and mentally is following the law of evolution, the law of biological recapitulation—he is living over the life of the race. His own fresh spark of life is being fanned by the same winds that coaxed the genius of his race into flame. Why then in our teaching should we not follow the same course? Give him generous conceptions around which the senses can wrap themselves. Let mathematics come finally to be the living spirit of a fully vitalized conception instead of an empty shell.

Mathematics, most of it, was not spun in its present form; it was the clothing of lusty physical facts. But when it was found that the same clothing could be worn by many facts and finally that it could even stand alone, with its fellows it was set up in an armory. But it takes a great deal of imagination to feel the glory of knighthood and battle through looking at armor; it is more likely to seem rusty and creaking.

It is obvious what ought to be done—in our teaching we must give mathematics a body. Throw up the windows and let in a fact or two—bare facts; turn them over, enjoy the mystery of their being, let the senses feast on their fatness, dance about them for pure joy of their wholesomeness and then finally fit them out decently and becomingly with a mathematical dress.

It is not easy to do this; it is easier to feed extracts than to provide the kind of food that the living body really demands; it is easier to put your hand in your pocket and throw two bits to an unfortunate than to give him the sympathy that he really needs. It is always hard to do the vital thing.

I will attempt to give an example or two. There is a little group of theorems in solid geometry upon which the subject of perspective drawing rests; the theorems in themselves are rather obvious, somewhat difficult logically, and students think them stupid, but they come to life most wonderfully when they are interpreted as the laws of perspective. Even the simplest is none too simple to be the hero in a paradox. The few times when I have had a class in solid geometry we have made a short excursion into perspective and while it necessitated the slighting of some other parts of the subject I have always felt that it was well worth while; and I venture to say that that is the part of the course, if any, that stands out in the students' memory.

The problems of descriptive geometry furnish a wealth of illuminating material. The very fact that you can draw, that the

use of ruler and compass gives you a freedom that you could not have if you were bound down to the results of pure reasoning, makes it possible to do in an elementary way most fascinating things—to build boats for instance and to do the curious feats of the tinsmith in fashioning metals into strange shapes. Nothing could give the student a better basis for analytical study, for analytic geometry for instance; for the subject-matter is now in mind and all that remains to be done is for the mind to take over that part of the process that has been performed by the ruler and the compass. The humble templet, for instance, which the tinsmith uses for cutting stovepipes, turns out to be our respected friend, the sine-curve.

If you will allow me I will give you as another example our experience in the university in teaching mathematics to the students of the college of commerce. These boys come to the university in most cases with minds peculiarly unopen to the influence of abstract mathematics. They are for the most part boys who look forward very definitely to a business career and the problems of the dollar are already uppermost. This type perhaps does not interest you; that is hardly the point, however. They will become men of weight in the community; shall we force a discipline upon them which is distasteful and unproductive of valuable results, or shall we take the material as we find it and adapt our instruction toward the point at which their minds are open? As an actual fact the situation in the university a few years ago was acutely painful and it demanded a radical treatment. So we said, "Very well, we will not teach you algebra, we will teach you bonds and sinking funds." So a course was laid out in which the subject-matter was wholly economic—the nominal subject-matter, yes, but the method was mathematical. We taught them the same things as before, theory of equations, logarithmic and exponential theory, series, binomial theorem, permutations and combinations, calculus. The theory of interest carried us into every department of algebra and as much farther as the spirit moved us to go.

The difference in the results, however, was very great. Where there had been indifference and painfully poor scholarship there arose at once alertness and vigor of thought, and the class instead of having to be dragged has in general to be held back. The new matter as it comes up is very largely anticipated by the questions of the class and the instructor is amused to be told that the course is the most "practical" one in the college—a

remark which of course only indicates that the work has reached a vital point.

The method is of course to introduce facts and problems of economics at once. If there happen to be lying around in the minds of the class any fairly good pieces of mathematical knowledge, they are fitted to the facts, but you may be sure that the instructor uses every opportunity to point out the incompleteness of the wardrobe and the alternative soon arises of letting facts go bare or else spinning some new mathematics. So we cheerfully sit down to spin and weave and the work goes on almost as properly as in any other mathematics factory—only we have to stop every now and then for "tryings-on." A few remnants we give in the goodness of our hearts to physics or psychology or any other deserving beggar, not because we could not use them, at least for neckties, but to encourage altruism.

And what have we when we are through? Well, first and most evidently, a fairly serviceable suit of clothes for an important part of economics, good enough if not used too hard and even with a bit of style. And what else? That is only part of the greater question: what are any of us getting from our spinning and weaving—only the clothes for our backs?

If there is one element more than another that characterizes our present age it is the consciousness that the life of the spirit is in the things of the world rather than by means of them, that life is only the spiritual side of living. If our culture is crude to-day it is because in the process of readjustment and assimilation it is all being boiled up from the bottom. We have been flooded with new facts and new conditions of life; the world has pressed in upon us and the old vessels with the old culture have quite overflowed.

And what does it all mean? A message of great hope, that culture is not a delicate plant that must be nourished with a favored soil and sun but that the roots of the spirit striking into any soil can find a nourishment that it can transmute into flowers. And that is why there is salvation for the bricklayer and the stevedore and even the college professsor and that is why you can teach a class bonds and have it turn into mathematics and that is why there is hope for the technical school.

I will not admit that even in the most utilitarian technical school something more than mere technique is not being taught, in fact, something more important. Technical schools are schools of culture or else the world itself is hopelessly wrong;

for a school is only a microcosm; the only difference is that we are playing with life, there are no bullets in our cartridges. It is not the misfortune of a technical school that it must concern itself with bricks and mortar and engines and bridges instead of with Greek, but it is its peculiar strength and good fortune to be able to distill a culture from such humble materials. Art is long and time is short and if we can live while we are preparing to live, if we can get our culture at the same time that we are learning to get our livelihood, we are not only doing something very thrifty in a world where there is so much good living to do but we are doing something that is apparently very much in line with the philosophy of the universe.

I am not speaking for a weakened mathematics; there is only one mathematics. Professor Keyser says, "Applied mathematics is mathematics simply or is not mathematics at all. The mathematization of thought * * * means the growth of mathematics itself, its extension and development from within; it signifies the continuous revelation, the endlessly progressive coming into view, of the static universe of logic; * * * the upward striving of thought everywhere to the level of cogency, precision, and exactitude." I am not speaking about mathematics at all *per se;* I am speaking for teaching mathematics so that it cuts through a real field of force and sets a current going in the spirit, for otherwise what is the use?

LEGUMES IN A NEW ROLE.

Everybody, nowadays, knows that legumes add nitrogen to the soil they grow in for the reason that they have certain bacteria living on their roots that take nitrogen from the air and fix it in the soil in a form that plants can use, but it is not well known that legumes, in some way actually facilitate the absorption of nitrogen by other plants when grown with them. Timothy grass grown with such other legume forage crops as alfalfa, red clover, and peas showed a gain in protein content of from fifty to one hundred and sixty pounds per ton, the protein, of course, requiring nitrogen in its composition. This gives an additional reason for the custom, common among farmers, of growing clover and grasses together. For more than a hundred years the fact that a legume might aid a non-legume to obtain a store of nitrogen when grown with it, has been hinted at, but it is only recently that careful experiments have placed the supposition upon a solid basis of proof.—*American Botanist.*

THE TIME-PLACE OF PHYSIOGRAPHY IN THE HIGH SCHOOL.[1]

By Kirtley F. Mather,
University of Arkansas, Fayetteville.

Of the proposing of reforms there is no end. In these days of reformative movements—political, social, educational, wise and otherwise—it is hardly necessary for a newcomer into the arena of reform to offer an apology for presenting his proposition. We have become so accustomed to the discovery that present conditions are entirely deplorable, that present customs are relics of barbarism, that we no longer are startled by such discoveries. It is, however, with a feeling of hesitancy that I approach the subject which has been assigned to me, for I appreciate that one who like myself is versed in a special scientific line rather than in the broad field of pedagogy can enter that field only by the courtesy of those whose experience therein is of long duration. It shall be my intention, therefore, to discuss the subject of the time-place of physiography in the high school from the standpoint of what is best fitted for the needs and development of the high school student rather than from the standpoint of the special teacher of that science.

Physiography as a science may be said to have had its origin when, at the beginning of the nineteenth century, Pestalozzi took the children in his school out into the fields, leading them along the streams, through the forests and across the hills, pointing out to them the facts of nature which they could observe. The science, however, did not begin to command much attention in America until, in 1893, the report of the Geography Conference to the Committee of Ten gave it new impetus. Three years later, 25½ per cent of the pupils in high schools were studying physiography, according to the report of the Commissioner of Education, and since that time it has been offered in the science course of nearly all high schools in this country. Of recent years there has been a growing sentiment against its continuance in its present position. How real this dissatisfaction is may be noted from the fact that just a year ago at the meeting of the Association of American Geographers a round-table conference was held in an endeavor to discover what was wrong with the teaching of this science. It was the general opinion

[1]Presented at the forty-fourth annual session of the Arkansas State Teachers' Association at Little Rock, Arkansas, Dec 27, 1911.

of those present at this conference "that there is dissatisfaction —in some quarters a good deal of dissatisfaction—with the results obtained from classes in this subject, but that the dissatisfaction is less serious and widespread than the opponents of the subject would have us believe."[2] Moreover, it cannot be denied that in great numbers of the high schools in America physiography as a school science has not lived up to expectations and has failed in becoming the success that was claimed for it a score of years ago. It is, therefore, a matter of considerable importance to those interested in secondary schools to inquire into the causes of this lack of success and to ascertain if possible what can be done to better the conditions as we now find them.

The true teacher has a threefold purpose in presenting a science course to his students. The least important of the three is the dispensing of knowledge. Around each of the natural sciences there has been built up a considerable mass of facts; with the most important of these facts the student should most surely become acquainted, but this is only the first step towards a scientific education. The subject-matter of science is only a part of science itself and to the high school student it is only of subordinate importance.

Far more important is it that in the acquiring of the facts of science the student should learn to think. A year ago the statement was made at the University of Chicago that "the mind was made for thinking and it enjoys that activity. The greatest danger in our educational work is that we stop the mind from thinking; we inhibit that process; we discourage it. Years of mechanically learning and reciting what is in the book have discouraged thinking, have really taught the pupils not to think. This process of education has taught the young people to believe that what they may be expected to learn is in some book, that what they may be expected to do is explained in some book or will be explained to them. It has stopped all independence in the intellectual process."[3] And it is largely in the study of science that the student must achieve mental independence, must set in motion once more the machinery of his mind. Upon the teacher of science falls a generous share of the responsibility of implanting in his students the desire and the power to think, to think aright and independently.

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[2]Salisbury, Educ. Bi-Monthly, vol. 5, 1911, p. 403.

[3]W. W. Atwood, School Review, vol. 19, 1911, p. 120.

But of still greater importance is the third purpose that the teacher of science should have. His students must have developed in them the scientific point of view. Few people in this busy world of ours have need to know the formula for the acceleration of a rifle bullet, but all of us need to know why it is that a certain thing is entitled to be called knowledge when something else is mere dogma or guesswork. Few are ever called upon to make use of the principle that the work a stream may do varies as the sixth power of its velocity, but all of us are called upon to weigh fact against fact, formulate hypotheses, and reach conclusions that are consistent with the facts we know. Mr. Dewey has crystallized this principle in a single sentence: "The future of our civilization depends upon the widening spread and deepening hold of the scientific habit of mind, and the problem of problems in our education is, therefore, to discover how to mature and make effective this scientific habit."[4]

With such purposes before it, the teaching of science becomes something more than an occupation—it is, rather, a mission in life. Surely, one with such a mission must look well to the choice of subject-matter in the presentation of which he is to endow his students with as much as possible of the method of science.

With reference to physiography in the high school, Professor Salisbury has made the statement that "no other study in the curriculum affords better subject-matter for the development of thinking power."[5] The facts of physiography are in greater or less amount the possession of every individual and they are of such a character that from them may be adduced exact and accurate principles of a general nature. The science is a broad one and touches us all in that it has to do with the surroundings in which we live and move and have our being. Theoretically, it should afford a most excellent medium for the training of a student in the scientific method of thought.

Yet, experience shows that in many instances the results achieved in its use are to say the least disappointing. If the statements of the foregoing paragraphs are true—and I believe they are—this disappointment must be the result not of conditions inherent in the science but of the way in which the subject is presented.

Foremost among the reasons that explain this lack of success

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[4]Science, n. s., vol. 31, 1910, p. 127.
[5]Jour. Geog., vol. 9, 1910, p. 61.

in the presentation of physiography is the prevalent idea that anyone can teach this science. No subject can be effectively taught in any school unless there has been special preparation in that branch of knowledge on the part of the teachers of that subject. Yet instances are not rare where physiography has been placed in the hands of teachers of stenography and in one case it was given to the football coach "because there was no one else to take it"! Failure to apply the same standards to the teachers of physiography that are used in the selection of teachers for the other subjects of the high school curriculum is responsible in large measure for the spirit of dissatisfaction that has arisen with regard to this science.

Again, the subject-matter of physiography *as presented* is to a considerable extent not adapted to the minds and needs of children. In most high schools the subject is taught in the first year and the pupils of the ninth grade are only children. The editor of the Journal of Geography states that "seven of the nine text-books in physical geography most used in American schools were written by college professors. All of the books unquestionably have merit; some are excellent; yet practically all of them would fit third year or fourth year classes better than first year classes. Several of these text-books, written for use in high schools, are used with satisfaction in university classes."[6] Many of the principles of physiography depend upon certain laws of physics and chemistry and can not be adequately grasped without a previous knowledge of those sciences. The child of the ninth school year can be taught by only the most skillful of teachers to see the real significance of the history of a river valley or to comprehend a cycle of erosion. Nature's laboratory is built on such a vast scale and so many complications enter into every reaction which takes place therein that it is difficult if not almost impossible for the immature mind of the child to comprehend the principles upon which its changes are based. As a result, it becomes necessary for the less skillful teacher of physiography to slur over the more technical phases of the subject, to omit the induction of exact and general principles, to depend upon the memorizing of "what is in the book." Consequently, physiography *as taught* in many high schools is not sufficiently scientific to be an adequate introduction for the student into the great world of science.

In the effort to contort physiography into the semblance of

[6] R. H. Whitbeck, Educ. Bi-Monthly, vol. 5, 1911, p. 408.

an introductory science there is grave danger that those phases of the subject which give it its great disciplinary and truly scientific value will be lost sight of. In the hands of only the most skillful teachers, well trained in earth science, can this danger be averted, and in such cases the success of physiography is always noteworthy. The average teacher with the text-books now in use is working under a great disadvantage in endeavoring to lead the immature and often unprepared child into a true conception of science by this means.

The case against the first-year position of physiography becomes even stronger when it is reflected that in all probability this tendency to regard it as an introductory science is in large measure responsible for the attitude on the part of so many school authorities to regard it as a subject which anyone can teach. No one would think of giving a fourth-year science to a teacher, not trained in that subject, "because he needed one more study to fill out his schedule."

The remedy for these defects is obvious. If physiography were placed in the fourth year of the high school course its students could bring to it the knowledge they had gained during the progress of their studies in chemistry and physics. They would have reached that point in their mental development where they would find themselves adapted to the text-books now in use. The seniors in the high school would be less apt to tolerate poor teaching and the change would greatly help to correct the feeling among principals, superintendents and boards of education, that little or no special training is necessary for teachers of this science.

Recognizing the fact that physiography is not a basal science, the recommendation to the Committee of Ten above referred to was to the effect that it should be placed in the fourth year of the high school course, but very few schools have followed this recommendation. In Indiana there are six high schools which have so placed this science and only one of them suggests a change to an earlier position in the course.[7] While it is true that certain phases of this subject are suitable for presentation in an introductory science course such as will be shortly outlined it is also shown by experience as well as in theory that the more important and more technical sides of the study with their almost unlimited possibilities for the development of the

[7] Ramsey, School Sci. and Math., vol. 11, 1911, p. 847.

scientific habit of mind should be synthetically approached from a foundation of physics and chemistry.

In the hands of a well-prepared teacher certain portions of almost any science could be presented in such form as to be suited to the needs and attainments of the high school freshman; but it should be frankly stated that such a course is simply an introductory science course and the student should not be permitted to think that in completing it he had mastered the science upon which it was based. The choice of the science to be thus presented as the foundation for an introduction to further scientific studies should be left so far as possible to the individual school. It should be made with reference to the abilities and tendencies of the teaching staff as well as with reference to the needs of the community and the preparation of the students. Two suggestions for such courses seem to me particularly applicable.

Such a course might be based on geography and should be planned so that the student would have his eyes opened to the great inorganic world about him and note its influence upon the races of men. He should know where great coastal plains are; what they do for mankind; how the mountains produce peoples and industries which differ from those of the plains; why desert lands give rise to nomadic tribes while sea-girt islands are the homes of sailors. He should get some idea of the climatic laws, something of the reason for winds and atmospheric phenomena, and in a very broad way he should learn something of the processes at work to change the earth and the results they bring about. He should, above all, become familiar with the locations of great cities, great nations, the political divisions of the earth's surface; with the peoples which inhabit them, the waterways and highways which connect them; and with the various productions which differing conditions make possible.

Or, such an introductory course might likewise approach the field of natural science from the organic side, acquainting the student with the great living world of nature and its dependency upon its inorganic environment. From the study of general biological material he would be led to a consideration of the human body and its many functions. Personal hygiene, including sex hygiene, should be taught. A study of preventable diseases would lead the student into an inquiry concerning his own surroundings, natural and artificial, and he should find out what he can do in the way of settling problems of ventilation and sani-

tation. Coöperating with health authorities, he should be instructed regarding higher standards of health and should catch a glimpse of those processes of nature upon which his life depends. Through all these channels he should come to recognize the important part which scientific inquiry into the world about us plays in everyday life; how it strikes home to his own individual comforts and necessities.

Either of these courses, or similar presentations along other lines, should be offered in the first year of the high school course and should be followed immediately and consecutively by more technical work in the various branches of science. Such courses should be recognized as merely introductory to further scientific studies. The first course suggested is no more physiography than is the second biology.

With such an introductory course it is evident that physiography should be subsequently treated synthetically after the students had been led up to it through their work in chemistry and physics. Presented in such a manner at the close of the secondary school's scientific training, the student whose education stops at that point would have acquired much of the scientific spirit of inquiry; his work in the sciences would have for him a practical application to the world about him; his appreciation of nature should be keen. At the same time, the student whose studies are continued in college or university would have a suitable foundation for further scientific investigations, or if he pursued other educational lines his preparatory school training would have given him that scientific habit of mind which every high school graduate should have. Nor must we forget the high school freshman who "drops out" at the close of the first year, for there are many such. For him, too, such an arrangement of the science courses as herein suggested is the best. The introductory science course would fit his needs far better than the courses in physiography that are taught in 90 per cent of our schools, for it could easily be made to avoid on the one hand the Scylla of lightly skimming over the surface of a really important science without the training in scientific thinking, and on the other hand the Charybdis of plunging him so deeply into a new and mysterious world that he is forced still further into the habit of depending upon "what is in the book."

Upon the sequence of presentation of the science courses depends in large measure the value of those courses to the student. To make iron-clad rules that would fit every school, regardless

of the vast differences in teaching staff, equipment, and students, would be an impossibility. In most schools, however, under the present conditions of youthful freshmen and the necessity before every science teacher of taking advantage of each opportunity for giving training in scientific thinking, it would seem that the beginning science course should be frankly of an introductory nature and that physiography as expounded in the text-books now in use should follow the courses in chemistry and physics.

ECONOMIC BIOLOGY FOR HIGH SCHOOL.

By Albert E. Shirling,
Manual Training High School, Kansas City, Mo.

The outline of a course in economic biology, as here given, is merely suggestive of the nature of the work that was tried out somewhat experimentally in the Manual Training High School, Kansas City, Mo.

It might seem that there was small reason for introducing the course, as the practical phases of the biological subjects are emphasized in the regular classes in botany and zoölogy, which courses are still continued. The course in economic biology merely emphasizes and enlarges upon the more practical phases of the subject-matter presented in the former.

There are several reasons for introducing the new course. It is observed that the popular misunderstanding as to the scope of the work undertaken in modern high school botany and zoölogy still prevails. Boys do not choose to elect these subjects, especially the former. There is a dearth of boys in the botany classes. The tendency of pupils is to elect those subjects which are more practical, and which they think will have direct bearing upon their daily life, for instance, typewriting, bookkeeping, etc. It was hoped that the new subject, under the name of economic biology, would sound more interesting to pupils when it came time to elect some science subject. It was hoped that from the title they would surmise a subject that concerned their welfare.

I am not sure that some other name might not have been better, such as "Applied Biology," but certainly not "Agriculture," for the city boy or girl.

Moreover, it has also been observed that many, especially boys, have a very strong dislike for doing the careful, painstaking drawing that usually forms a part of botany courses. The new course requires no drawing. There is considerable laboratory

work with specimens, but always a test of observation power in answer to oral questions given during the study.

Notebook work consisted of reports on field trips; home experiments, experiments done in the laboratory; brief discussion of subjects illustrated by lantern slides and summaries of the topics studied. The pupils were helped and directed in these latter by being given a series of questions, the answers of which formed the basis for "notes" on the subject.

Some difficulty was experienced in the lack of text-book or definite references for pupils to make outside preparation. Frequent use was made of agricultural bulletins. Lantern slides were used occasionally; a series on most of the subjects was used for reviews.

It is difficult to do much field work with city children, but so far as possible field trips were taken; occasionally on school days, but more frequently on Saturdays when all enjoyed the long tramp and the camp fire lunch.

The results were somewhat gratifying. The course was purely elective, but the class became full and was closed the second day of the fall enrollment week. More boys were enrolled than in any other two botany classes. The familiar, practical treatment of subjects like forestry, soils, insects, etc., as they might relate to city conditions seemed to make the study seem worth while to the pupils.

Outline for Course in Economic Biology.

(One Year.)

I. Foliage Study.
   1. Nature of a leaf; arrangement. Activities.
   2. Experiments illustrating leaf activities.
   3. Field work.
      1. Foliage of park shrubbery.
      2. Special study of particular tree.
      3. Formal beds of foliage plants in park garden.
   4. Naming trees and shrubs by their leaves.

II. Weeds.
   1. Weed census of some convenient locality, as vacant lot, back yard, street parkway.
   2. Nature of weeds.
   3. Kinds of weeds as to duration of life.
   4. Methods of combating and exterminating.
   5. Uses; possibilities of improvement for use.
   6. Special reports by pupils on certain common weeds, report to include—habitat, annual, perennial, etc.; means of spreading and reproduction; special means of self-protection; how to combat them.

III. Insects.

1. Laboratory study of representatives of each of the principal groups of insects.
2. Observations and laboratory work on life histories of insects, conducted in laboratory.
3. Study of Economic Insects.
   (Written reports on about twenty insects; report to include economic importance; life history and means of combating.
4. Demonstration and discussion of mounted specimens and of lantern slides of economic insects, life histories, etc.

IV. Forestry.

1. Begin listing tree of Kansas City, locating those more rare.
2. Field trip for identification and study of trees of Hyde Park (60 species found).
3. Pressed and labeled specimen of leafy twig of twenty trees.
4. Properties and uses of certain trees.
   1. Trees used for parkways and lawns.
      What trees are permitted along street parkways? if any are forbidden, why? Regulations concerning planting, distance, etc.
   2. Commercial importance of certain trees.
   3. Practical and National Forestry.
   4. Study of Wood Sections.
      1. Study of transverse, radial and tangential sections of oak. (Without microscope.)
      2. Study of "grain" of hard pine and other woods.
      3. Veneers, stains, etc.
   5. Pruning.
      1. Natural pruning—how brought about.
      2. Artificial pruning, why?
      3. Methods of pruning, including general methods and methods for particular plants, as fruit trees, shrubbery, vines, etc.
      4. Pupils provided with mimeographed sheets of drawings of trees and vines and required to mark where pruning would be advisable and state reasons.

(The following topics also were included, and discussed with reference to their application to the interests of city children. They are not outlined because of lack of space.)

V. Soil.
VI. Home Gardening, Flower and Vegetable Gardens.
VII. Seeds and Germination.
IX. Plant Propagation.
X. Plant Breeding.
XI. Birds.
XII. Noxious Mammals of this Region. Means of combating.
XIII. Reptiles. Brief discussion of the nature of those found in our woods and parks.
XIV. Fungi, including: Bacteria, Yeast, Molds, Plant Diseases, Fungus Diseases of Forest Trees.

CORRELATION OF HIGH SCHOOL AND COLLEGE CHEMISTRY FROM THE HIGH SCHOOL POINT OF VIEW.[1]

By H. L. Geesling,
Instructor in Chemistry, Elgin High School.

The question, "What amount of the work done in chemistry in the high school should be credited by higher institutions of learning, so that a better correlation and a less duplication could be brought about?" has been largely discussed from various angles; so I do not attempt the task with the hope of presenting much that is new on the subject, but more with the view of turning over the vast amount that has been said, with the hope that I may still find an angle from which it has not been approached that will help in finding a satisfactory solution to the problem.

How then does the end in view from its teaching in the high school differ from that in college? The majority of college students who take up the study do so because they expect to use it more or less in the work which they have outlined to follow through life; with them, as a rule, it is one of the essentials and they are after it for the sake of its knowledge, for it is a prerequisite to their work as chemists, engineers, physicians, etc. The point of view of the teacher of such a course then must be to cover the whole ground thoroughly and see that every subject is enlarged upon; their work being largely one of distribution of information.

On the other hand, the high school teacher is not concerned with making chemists any more than lawyers. The student is not taking the course with that aim in view. The teacher is concerned chiefly in preparing the student for life, secondarily in teaching chemistry.

He teaches it as a means of sharpening the student's power of observation, by bringing him face to face with the unity and harmony of nature, and leading him to see with his own eyes, investigate things for himself, and thereby gain useful information concerning the problems of everyday life, and by so doing develop within the student reasoning and power.

I believe our courses in high school then to have two ends in view: to help fit the boy and girl for living and future usefulness by directing their thoughts and giving them power, and at the same time so much knowledge as will be of practical use to them.

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[1]Paper read before the Illinois High School Conference, University of Illinois, November 24, 1911.

The question of correlation of high school and college chemistry is not one that can be decided on first thought. If we should ask the question, "Should high school and college chemistry be correlated?" I believe we would be safe in saying that nearly all of the high school teachers would quickly answer in the affirmative, while, on the other hand, the college instructors would most likely answer in the negative. Before we can rightly draw a conclusion there are several problems concerned of more importance than may seem on the surface. Are we right, or are they?

In order to get at the subject and gain some idea of conditions as they really exist, both in our high schools and in our colleges, I sent a list of questions to twenty of our leading colleges, and a somewhat similar list to twenty high schools. I varied the institutions as to locality and type, so that their practices would, I believe, fairly represent the present practices as they really exist.

Let us look at the situation then as it exists in typical institutions of higher learning and typical high schools. One of these questions sent to the colleges was: "Do you require the student who has taken chemistry in the high school to take general chemistry again, if he wishes to continue the subject, or may he go on with more advanced work?" From the replies I received the following information concerning the attitude of the various colleges upon this subject and others closely related:

Brown University requires them to take general chemistry again, but if the student submits to examination and passes he may go on with advanced work. They went further and said that all parts of the work covered in high school had been unsatisfactorily done, and that the pupil understood neither theory nor practice.

University of Pennsylvania requires them to take general chemistry again without exception.

University of Michigan has a special course for such pupils and they can finish in half a year what beginners require a year to do.

Ohio Wesleyan said: "A few of the best students go on with more advanced work," stating further that too much stress was laid upon atomic theory, the use of symbols and formulas instead of names of elements and compounds.

Northwestern stated that they had a second year course for such students.

Chicago states that those who have spent one full year in high

school chemistry complete in two terms what would otherwise require three.

Wisconsin requires general chemistry to be taken again, but gives those who have had high school chemistry more advanced laboratory work. They say they can see no difference in their ability after about two months, but they furthermore add that the work done in the high school is not "unsatisfactory" for high school work.

Harvard states that those who have passed the entrance requirements take more advanced laboratory work, but take the same lectures as those who have never studied chemistry. They are also allowed to begin organic chemistry in their freshman year, but say their work in qualitative analysis has not proved successful.

The answers from the remaining twenty institutions are practically the same, and these will suffice for a general notion as to how the various colleges stand on the matter. Out of these twenty colleges eight make no specific provision for students who have had chemistry in secondary schools; three excuse them from elementary work after a special examination; six provide special instruction in both laboratory and lectures. Out of this number six answered the question, "Do you think there should be a correlation of high school and college chemistry?" in the negative, and they were unanimous in saying that the high schools were attempting to cover too much ground and consequently were covering but little thoroughly.

Out of the twenty high schools written, nineteen were very decided in their views that there should be a correlation, one said, "No."

To the question asked them: "What do you think should be the aim and scope of high school chemistry; and on what do you place the most stress?" I received quite an interesting mass of conflicting views; enough to indicate that the field of high school chemistry is by no means decided upon. Some said they placed the most stress on theory; some principles; some descriptive work; others, industrial application; others, laboratory work, etc., etc., and scarcely any two agreed as to what should constitute the high school course.

It is this lack of definiteness on the part of the high schools themselves that is to a large degree responsible for the conditions that exist, and the attitude that the colleges have taken; and in many respects their attitude is just.

Can we reasonably expect the college to plan a course to fit the various students that come to them, some having had this, some that, and some the other thing, with but few having had enough in common that they could build upon?

To me, it seems that it is first up to the high schools to adjust themselves; to fit themselves to something, so others will know where to find them, and so they will also know where to find each other. Do their part first.

The result of this investigation, though I confess somewhat limited, would seem to indicate that the high school courses have failed to furnish much in common that would be a substitute for any great amount of college work. This brings me to the questions, "Why have we failed?" "What are the defects?" and "How remedy them?"

The defects in the teaching of chemistry cannot always be those that are well defined and which can readily be detached from the mass of excellence with which they are connected. It is very difficult to secure an agreement as to whether a defect is really a defect, for the minute you prove absolutely that it is someone else proves it to be a virtue. Hence it is not easy to discuss the defects in the courses in chemistry, as offered, and the defects in their teaching. Therefore, I do not attempt to refer to everyday and commonplace defects, of which there are many, but refer to the general conditions as they really seem to exist. Among these the following might be mentioned which call for some consideration at this point:

FIRST: Our courses in chemistry have failed to serve the needs of the individual.

SECOND: We have been too much content with following old-time methods.

THIRD: We have been trying to cover too much and have covered but little thoroughly.

That we have been accustomed to dealing with pupils in the aggregate rather than the individual, all will agree. Not only does this apply to chemistry work, but to the other courses as well; but if there is any line of work more than another in which we must deal with the individual, it certainly is in the sciences as a whole and chemistry is no exception.

Let us look at the conditions as they confront the high school teacher. He is often required to teach several other studies besides chemistry; his equipment in chemistry is often very meager for doing successful experimental work; besides, his class is

composed of not only the boys and girls who are intelligent and ready to put forth their best efforts, but those that have but little taste for chemistry; the idlers and lazy ones; those who are not in school for work but there because they were sent; some interested in music, some athletics, etc., etc.—in short, he finds his classes drawn from various stratas of society, representing various sorts of natural and acquired tastes, talents, and capacities. He is concerned with helping mold out of this mass a citizen of worthy type and also to help fit him for life and future usefulness in the busy world around him. Our courses for doing such, we might say, have been shaped to fit the needs of an indeterminate quantity called the "average student," and we have given to this indeterminate quantity a certain amount of reason, intuition, and judgment rather than shape the course to the individual as he really exists. We have been spending so much time in teaching facts that we have been neglecting the more important duty, which is to help the student find out for himself, to know and use the power that lies within him. The value of chemistry as it concerns the boy is not measured by the number of formulas and chemical laws he may be able to repeat, but by his power to observe and apply these laws to the phenomena around him.

If the chemistry course is given for the pupil, why not fit it to the pupil so that he will derive something from it rather than fit the pupil to a course made to suit the fancy of some college professor? The colleges to a large extent have set the pace and are asking us to follow and in order to meet their requirements we have been throwing the fragments and carved out pieces of chemistry at the student, out of their proper relations, to be learned and assimilated, hoping that enough will fall in proper line for admission.

In the high school we are endeavoring to teach chemistry to this multitude with varying aims, scarcely one tenth of whom will have the fortune of going to college. Whenever our courses are planned exclusively for this one tenth and ignore the claims of the other nine tenths, there is room for criticism. The three great industrial interests—commercial, manufacturing, and agricultural—demand a share of our attention, for their demands are just and have power behind them. We must teach chemistry as it should be taught to high school students, without considering the fact that some may be fortunate enough to go to college.

The second defect mentioned was that of following old-time

methods and too close an imitation of others. A course in chemistry that served the needs a few years ago may not necessarily serve the needs to-day. With the rapid developments along commercial, agricultural, and industrial lines, new methods must be adopted to serve their demands. Text-books used five or six years ago, while they presented the methods of that day exceptionally well, do not present up-to-date methods often that must be used to-day, and this conservativeness on the part of the teachers in keeping abreast of the times, by adopting up-to-date books dealing with new chemical phenomena and methods, has been a hindrance in doing the best work. A course planned for one school may not work in another, and a course given in one section of the country may not be the one to adopt in another: there would seem to be to some extent a local matter concerned.

With the rapid centralization of population, and the creation of new and fascinating problems in our cities, the result has been that courses have been laid out to deal with these problems, and through the desire of imitation, the high schools of country districts have, to a large extent, patterned after them; and as a result courses have been installed to serve a totally different type; courses which in many instances have been subversive to the pupils' interests and out of sympathy with their environment. Why should not our courses deal with materials that lie close at hand, and with which the student is in sympathy, rather than attempt to model after those that are aimed to fit pupils of entirely different desires and fancies? The same principles could be involved, and the same result will be reached, while the student is dealing with something about which he is concerned, and something with which he is already familiar to some extent.

The schools mentioned were unanimous in saying that the high schools were attempting to cover too much ground. Are we not expecting too much from the high school students as a whole when we attempt to take up all the matter given in our standard texts, and expect all to master the subject in one year? Several can do it, and I do not hesitate in saying can do it well, but a large number cannot, and too, one year is a short time when we consider the vastness of the subject.

Let us ask the question, "Why does this condition exist?" It is due partly to what might be called a "Chinese characteristic" that has permeated our educational atmosphere, that what went into the training of the past generations must also form a part

of the present; study everything from the theories of the alchemists to the properties of radium, the ion and electron.

Again, it is due in a large part to our efforts in attempting to meet what the college thinks should be covered; just so much theory, work so many experiments, and just such ones; by meeting these requirements and these only will admission to the more advanced precincts be given. I do not lay the blame on the college for this existing condition so much as I do on the high schools. We have the same privilege of speaking as they. Let us wake up and have backbone and persistence enough to force our own convictions, force them in such a way that we will command attention.

Again, the teaching of chemistry to pupils of immature minds presents some difficulties, and the subject itself abounds in difficulties to a large part of high school students.

In nearly all subjects taught, the student has generally gathered his information from the book and that alone. Its printed pages he has been diligently trained to master. It is this textbook habit, to which the student has been accustomed, that works the great hindrance at first; getting him away from it and leading him to really observe and investigate for himself, rather than fill his mind with chemical calculations, theories, and arbitrary rules, formulated by someone else, is no easy matter. And besides, atoms, molecules, equations, ions and the like he never heard of before. No wonder he is slow in understanding what it is all about. The apparatus likewise is as strange; test tubes, beakers, balances, etc. Is it any wonder it all seems strange?

Keeping in mind then the new things with which the student must become acquainted, the methods used in acquainting himself with them, the immaturity of the pupil, the principles underlying the chemical processes, and the somewhat limited field for finding applications to these principles that are within his environment, is it not too much to expect the more difficult principles to become really fixed in their minds in one year?

I realize the danger in drawing conclusions from only a very limited number of facts, but, if I were to draw conclusions from the reports received from the twenty high schools written, I would say that the methods used in carrying out the fundamental aims of our high school chemistry courses have degenerated into two extremes. On the one hand that of time wasting. In many instances it would seem that instead of insisting that our pupils master the underlying principles we have been making the ex-

periments that deal with them merely courses in scientific dish-washing. We have the student bring hydrogen and oxygen together as though the only thing to be derived from such is to hear the explosion and furnish amusement, and giving about as much an idea of the principle involved as a child would have of the report of a shot gun. This sort of experimenting has nothing to commend itself. Neither is it training the student to think, or giving him much of a scientific outlook upon the world.

On the other extreme, our courses are failing to give the spirit and grasp of the underlying principles, because there is a lack of understanding on the part of the student. We are in many instances presenting principles beyond the power of the student to grasp. The course then becomes useless drudgery on the part of the student for that reason. Make the course intelligible to him and interest will be created; create interest, but interest in chemistry and not amusement, and the principles will be grasped. We must teach principles, but we must keep these principles in close touch with their application, and not expect the more difficult ones to be mastered at first, but attain these higher ends gradually as a final and not an immediate result.

I have endeavored thus to somewhat outline conditions as they appear to be. The result would seem to indicate that there has been a wide difference of opinion as to what should constitute the high school course; so wide a difference that the various students have had such a small amount in common that could serve as a firm foundation for advanced work, that this amount has been slow in receiving consideration from the colleges and it has therefore been necessary to duplicate work.

This brings me to the question: "Is there not ground enough on which to build a course that will meet the needs of the student who does not go to college; meet his needs as he is really situated in his environment; a course that will meet these needs in the best possible way, and at the same time be a foundation firm enough on which can be added a more thorough course, if desired, without having to cover the same ground *again?*"

How could our course be arranged to do this? What would these better conditions be like? These are questions which require some consideration, but let me add that whatever is best for the student who goes to college is, I believe, to a large extent, best for the one who does not have such opportunity.

I would not wonder at the colleges saying our students were materially deficient, if all of them who have attempted to get

chemistry in high school would present themselves for a continuation of the work in college. But such is not the case. It is usually only the student that has made a good record that will have a sufficient liking for it to want to continue its study in college.

By giving our better students a chance, I feel safe in saying that they can master the underlying principles in such a manner that it would be a pleasure for our colleges to have the opportunity of going into still more advanced work with them. As long as our classes are composed of both the strong and the weak students, there is a tendency to devote more than the pro rata of time to the weaker ones, and we are therefore consuming time that, if spent on students of a more equal caliber, could be used, I believe, to a better advantage. By dividing our classes then in schools where the numbers would justify such, we would be giving the better students such work as would add most to their general information, and at the same time could go deep enough into the underlying principles to furnish such a grasp of them as would be firm enough for a foundation for more advanced work, if they wished to take up such; while we would be giving the weaker students, even if the work would be more elementary in character, all it is in our power to give them. By such courses we would be more nearly accomplishing both ends in view, for those who would wish to continue its study would most likely fall under the first class. Such students would find no difficulty in handling more advanced work.

Better conditions would be those that meet the demands of the majority, while at the same time would suffice for the more fortunate who enter college, and give them ample preparation for a more advanced course at once. I believe such conditions could be brought about and the differentiation between the work of those destined for college and those who are less fortunate need not be so marked as at present.

If I might suggest a remedy and course to bring about these conditions without being misinterpreted, it would be a course that would include the fundamental principles, but not the more complex principles and theoretical conceptions; the maturity of the pupil and his environment being always kept in mind. A course that would contribute most to the students' general information and culture, by acquainting him with a wide range of chemical facts, and at the same time train his power of observation and capacity to associate new data from laboratory

experiments with those already in his knowledge. Such would serve as a basis for adding more advanced principles and theories, and at the same time would give a fund of knowledge applicable to everyday life.

Before passing, I feel that a word concerning laboratory notebooks might not be out of place. As to what they should contain, and the care used in keeping them, there is a variance of opinion; but if we require the notes written in full, and above all, neatly done, we are at least giving a training in English and neatness that is of as much value in creating citizenship as the extra part of an experiment that might be performed, if done otherwise, for it is as much our duty, as high school teachers, to create right habits of work as to teach our subject.

In conclusion, then, how can we make the high school and college work more mutually helpful?

First: By the high schools agreeing on what they are to cover, and planning the work covering this field more to meet the needs of the individual.

Second: By offering only what can best be assimilated, and only so much as can be taught well in the time allotted to it.

Third: By a willingness on the part of the colleges to recognize and utilize every bit of work thus covered.

Let me emphasize finally that on the whole I believe the work of high schools should be simple, and to a large part descriptive rather than theoretical; that it ought to be planned irrespective of the idea that some will attend college; and should be kept in close correlation with the work in physics and biology.

CAMBRIDGE BOTANICAL SUPPLY COMPANY'S NEW CATALOGUE.

The Cambridge Botanical Supply Company of Waverley, Mass., has just issued a new catalogue. It is issued in sectional parts, on the loose-leaf plan, with cover for binding.

It is issued in four parts: Botanical Supplies, Plant and Zoölogical Material, Physical Apparatus, and Chemical Apparatus and chemicals.

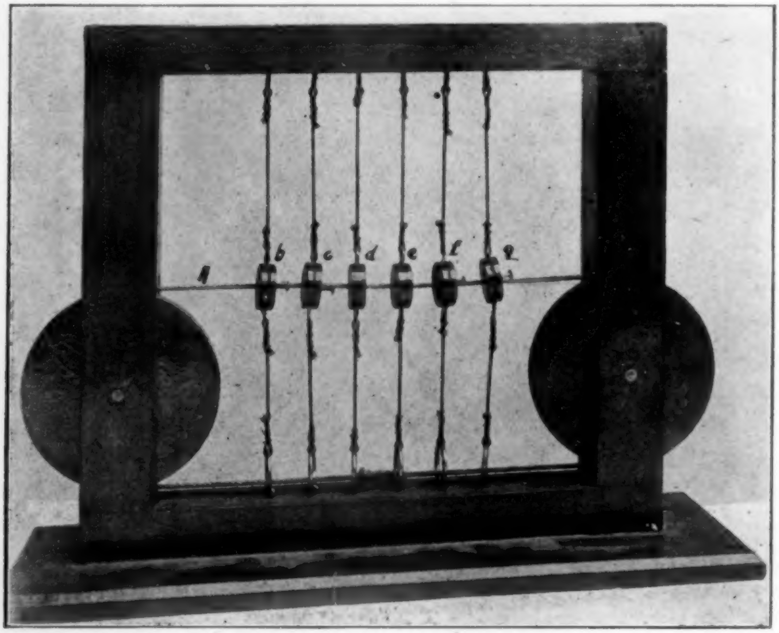
This is a valuable innovation in catalogue-making, as revised sheets and new descriptive circulars can be easily bound in, thus keeping the catalogue up-to-date with little trouble or expense.

The section on Chemical Apparatus contains eighty pages. It contains everything that the average high school laboratory needs.

CHARGE AND DISCHARGE OF CONDENSERS ILLUSTRATED BY MEANS OF AN EASILY CONSTRUCTED MECHANICAL MODEL.

By Charles F. Bowen,
Manchester, N. H.

Mechanical models to picture to the eye the processes attending the charge and discharge of condensers have been constructed by Sir Oliver Lodge, the famous English physicist, but the one shown in the accompanying cut, designed and constructed by the author along the general lines advocated by the former, is believed to be the only one of the kind in the country. In the work of teaching classes in physics or tracing the mysteries of the entrancing field considered under the great caption of "Potential," for the benefit of those other than science students, this little contrivance has been found to be of the utmost utility and a description of its construction and use is given herewith that others engaged in this work may design similar instruments if they wish.



In the figure, A is an endless cord, heavy fish line, and represents a current of electricity. *b*, *c*, *d*, etc., are successive atoms of the conductor or nonconductor, according as the case may be, and consist of short wooden cylinders, punctured in the

center along the axis and held from above and below by elastic bands attached to small screw eyes. The two center "atoms" are made of iron to give the system inertia and are made to resemble closely the wood counterparts by being coated with base and graining colors.

The elastic bands form the simplest picture now possible of the medium surrounding bodies. The lower set of bands is broken near the bottom to permit of the passage of the endless cord, this result being obtained by inserting small rings through which the cord threads. This cord, representing the current of electricity, passes around small grooved, wooden pulleys at each side. The punctures in the wooden "atoms" are of such size that the cord will slide through without much friction, representing by this action the free passage of an electric current through a conductor. The heat of friction may be taken to stand for the ohmic resistance of the circuit.

When considering the case of a nonconductor the atoms must be clamped to the cord, for the current in such a case is unable to flow through. This is done by inserting into the openings, alongside the cord, small wedges which prevent the rope from moving. The model now represents a condenser and it is given its charge by a battery whose E. M. F. is represented by a force used to move the cord. The strain of the dielectric or medium is indicated by the distension of the elastic bands. Clamping the cord corresponds to making the resistance infinite.

If now this resistance be suddenly made very much smaller, in the case of a condenser by allowing a spark to pass from one coating to another or in the case of the model by unclamping the cord, the condenser discharges. Following this process as depicted by the model, it is seen, as might have been expected, that when the knobs fly back from their strained position they do not stop immediately at the central point, but oscillate back and forth several times, a state of affairs brought about by virtue of the inertia of the moving masses and the elasticity of the cords supporting them. In an electric condenser the same conditions are to be observed. The discharge is essentially oscillatory, only very much more rapid in movement and shorter in duration.

Upon what does the rate of oscillation depend? Consider the model. The stronger the elastic cords and the less the weight of the "atoms," the faster the vibrations. Given this data, it is not difficult to show how for a perfect machine the period might be computed beforehand. The electrical problem and its solution are

precisely analogous, only that instead of elasticity static capacity must be used and in place of the inertia of the "atoms," the electromagnetic inertia or self-induction, must be used. It is readily seen that increasing either of these quantities diminishes the frequency of the oscillations. The making larger of the capacity is the same as making the elastic bands longer, while increasing the inductance corresponds to the making heavier of the knobs.

The static capacity may be increased at will by making use of larger plates or a larger number of them. In making use of the latter method it must be remembered that there are two ways of connecting up condensers and which have widely different results. If two equal condensers are coupled up in series, so that the inside coating of one of the jars is connected with the outside of the other, it is found that the combination has but one half the combination of one of them. If, on the other hand, they be hitched in parallel, the combined capacity is twice that of either one alone. The former method is useful where we have condensers not able to stand a voltage under which it is desirable to use them. A number may be arranged in a series or cascade and the pressure upon each thereby split up. An example of this would be in the case of a transformer such as is used in wireless telegraphic work, and giving a secondary voltage of 30,000. The condensers on hand are constructed so as not to stand more than 20,000 volts. If two of these are connected in series, each will have to stand but 15,000 volts.

Referring back to the model, increasing the electromagnetic inertia of self-inductance, is analogous to affording the current more space to magnetize, since it depends upon this action of the current upon the surrounding medium. This result is obtained by inserting coils of wire in the circuit.

The well-known equation for simple harmonic motion is well known from physics text-books and is to the effect that

$$T = 2\pi\sqrt{\frac{m}{k}}$$

After making the necessary substitutions as just outlined we find that $T = 2\pi\sqrt{LC}$, where L is the inductance in henries and C the capacity in farads. This is called the "fundamental equation" in wireless telegraphy and is used, after being reduced to more simple units, in every wireless experiment station in the land.

One does not need to be and expert carpenter to build a condenser model. The one shown in the picture is made of soft wood.

The expense is trifling and after the little machine is given a coat of shellac or cherry stain, then varnished and baize cloth gummed to its base to prevent the scratching of a lecture table, it will be not only an ornament to the furniture of a class room but a useful implement in inculcating the facts in the subjects of condensers and oscillators.

A CONVENIENT FORM OF LIQUID RHEOSTAT.

By S. R. Williams,
Oberlin College, Oberlin, Ohio.

Many small laboratories often want an electric current of small ampereage but a voltage larger than the few dry cells at their disposal will give. The electric lighting circuit is usually available but unless a proper resistance is put in series with the circuit the safety fuses are liable to go.

The following form of a liquid rheostat has been found so useful in the laboratory for the above and other purposes that I take this opportunity to describe it. It may be familiar to others although I have never seen any description of such a modification.

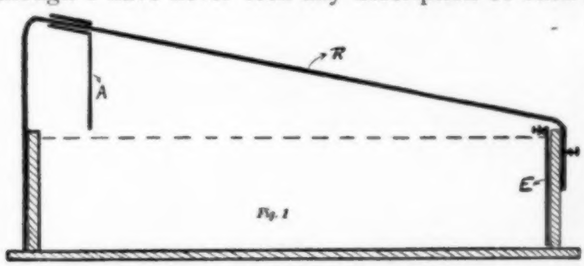


Figure 1 shows a cross section, lengthwise, of a wooden box, 40 inches long, 5 inches wide and 6 inches deep, made from ordinary pine boards. A and E are the two electrodes which may be made from copper strips or from the carbon plates one finds in a wornout dry cell. E is attached to the inside of one end piece of the box while the other is fastened to a short piece of gas pipe which slides on an iron rod, R, bent in the shape indicated in Figure 1. I have used one half inch rods for R and found they worked satisfactorily. Of course brass would be better. As A moves toward E the resistance of the portion of electrolyte between the two electrodes decreases, both by decreasing the length and increasing the cross-section of the conductor. If currents of a few tenths of an ampere are wanted, I have found that ordinary tap water worked well for

Fig. 2

the size of box indicated. If larger currents are wanted it is better to add a small quantity of sulphuric acid. Figure 2 shows one of the end pieces of the box and also indicates that the iron rod rises about twice the height of the box before being bent over at the higher end of rod. This brings A, when in contact with E, so that they are about at the same depth in the electrolyte.

To make the boxes water tight I have boiled them in paraffine until the air and moisture were all out and then allowed them to cool. After such a treatment the wood will be saturated with the paraffine and will not warp and split from further seasoning. This makes a box which has good insulation and will not leak. I have had one in use in the laboratory for several years and it has not leaked yet. This method of treating wood with paraffine will be found useful for many other purposes about the laboratory.

STUDENTS' SELF-FILLING BAROMETER.

By F. R. Gorton,
State Normal College, Ypsilanti, Mich.

The demands of a high school laboratory include not only a working barometer but a students' piece capable of illustrating the barometric principle. The usual experiment of filling a tube with mercury and inverting it in a dish of mercury is both wasteful and unsatisfactory. The loss of mercury and the difficulty found in keeping it clean and dry are such as to prohibit in many laboratories the use of this experiment as a student exercise. It is with the view of obviating these difficulties that the self-filling barometer tube has been designed. The construction will be seen to be simple and is such as to keep the mercury clean, since it comes in contact with glass surfaces only.

Figure 1 shows the form of the cistern C, which is open at A and joined to the barometer tube B. By means of two or three brass clips, a meter stick is attached firmly to tube B. In this cut the tube is shown in the first position and filled with mercury. A quantity of mercury in the cistern is also necessary.

Figure 2 shows the tube mounted on a standard G by means of a screw S through the meter stick. It is plain from Figure 1 that a rotation of the tube in the direction shown by the arrow will cause the mercury in the cistern to flow to the end of the tube which it keeps completely covered. As the tube approaches

the final position, Fig. 2, the mercury falls to the barometric height, which is obtained by reading the positions of the two mercurial surfaces. A stop is placed at F to prevent rotation in the wrong direction, and a large leather washer at S affords sufficient friction to keep the tube in any position. A small weight

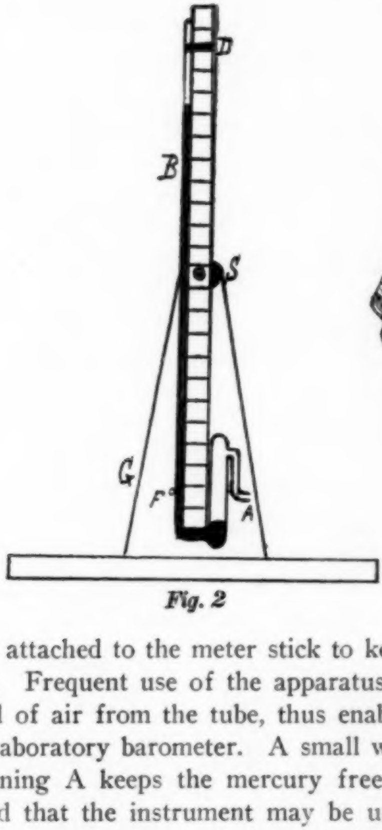


Fig. 2

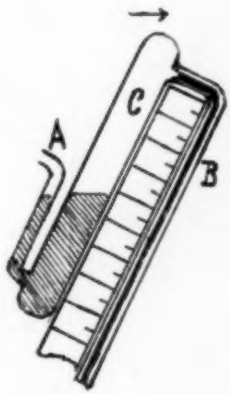


Fig. 1

may be attached to the meter stick to keep the center of gravity near S. Frequent use of the apparatus results in the thorough removal of air from the tube, thus enabling the device to serve as the laboratory barometer. A small wad of cotton inserted in the opening A keeps the mercury free from dust. It will be observed that the instrument may be used as a manometer for showing the pressure of air in a partial vacuum by simply joining the side tube A with the receiver to be tested.

The Chicago section of the American Mathematical Society held its thirtieth regular meeting at the University of Chicago on Friday and Saturday, April 5, 6, 1912. There were fifty-three members present and twenty-nine papers were read at the four half-day sessions.

THE USE OF SPECTACLE LENSES FOR THE CORRECTION OF REFRACTIVE AND OTHER ERRORS OF THE EYES AND THE INSTRUMENTS USED FOR DETERMINING SUCH ERRORS.[1]

By Arthur F. Amadon,
Boston, Mass.

The use of lenses for the correction of ocular errors and for the improvement of vision goes back to prehistoric time. During the excavations of the ruins of ancient Nineveh a rock crystal lens was found, and in those early days the principles of reflection and refraction of light must have been well known. In our own England it is a matter of record that Roger Bacon, when he occupied the chair of philosophy at Oxford, obtained some fine glass from Belgium and from this, with his own hands, made some spectacles by grinding and polishing the lenses, which were afterwards given to an elderly friend and worn by him previous to 1286. Charles V, after his death in 1558, left among his valuables twenty-seven pairs of spectacles. But it is only within the memory of the present generation that the refinement of ocular corrections have been possible, owing to more perfect knowledge of the conditions within the eye, more refined methods of examination and greater skill in lens making.

All combinations of convex, concave, cylindrical, and prismatic lenses are used for the correction of ocular errors, and some ingenius devices have been used for properly adjusting and holding properly before the eyes the various combinations of lenses, from the clumsy split bifocal of Benjamin Franklin to the elegant invisible bifocal of to-day. The unit of strength of spectacle lenses is the lens which will focus parallel rays of light at one meter, or forty inches. This unit is called the Dioptric. A half Dioptric lens has half the strength and focuses light at two meters or eighty inches; one that focuses at half a meter is a two Dioptric lens, etc. Prisms are numbered according to their ability to deflect light, 1°, 2°, etc.

In speaking of the eye as an optical instrument I wish to emphasize one feature, *viz.*, that, except for the tunics or limiting membranes, the eye is an elastic and fluid body, each surface of transparent tissue being a refracting surface. In front of the eye we have the cornea, a tough, resistant, almost perfectly trans-

[1] An address delivered before the Eastern Association of Physics Teachers at the Astronomical Laboratory of Harvard University, Cambridge, Mass., Dec. 2, 1911.

parent tissue, the front and back surfaces parallel and offering a strong convex refracting surface to entering rays. Posteriorly it is in contact with the aqueous humor—a fluid of the appearance and consistency of water, hence its name, the aqueous. Limited by the cornea in front and the crystalline lens behind, it is in effect a strong concavo-convex lens and a powerful refracting medium. Behind this is the lens of the eye, enclosed in its elastic capsule, a semifluid, transparent, sticky substance, having the outlines of a double convex lens. It is supported at its edges by a ring of muscular tissue, called the ciliary ring or the muscle of accommodation. This ring, by its contraction, diminishes the circumference of the lens and allows it, by its own elasticity, to become more convex and therefore more highly refractive. Inasmuch as this increase of convexity and increased focusing power necessitate muscular contraction of the ciliary ring, which must be constantly exercised and under constant variation during accommodation. it is not difficult to understand why the accommodation becomes weary and exhausted after long-continued use of the eyes, and particularly so in far-sighted eyes, which require constant focusing in order to bring the image on the retina at all. The lens is the only part of the eye that can be made to change its curvature at will and the only accommodative part of the eye. Behind this is the vitreous, a gelatinous, somewhat organized mass which fills the ball back of the lens. Thus we have a series of lenticular bodies, in contact with each other, each of different refracting power, not unlike the series of lenses found in high-class telescopes or microscopes. They are held firmly in contact with each other and under considerable internal tension.

A perfectly refracting eye is one in which parallel rays of light, on passing through the eye, are brought to a focus upon the retina without material accommodative effort, with the lens in its flattest condition, and with the muscle of accommodation relaxed.

A far-sighted eye is one in which the refracting media do not bring the rays of light to a focus far enough forward to form a perfect image upon the retina, and the accommodation must be exerted in order to give clear vision. This accommodative effort in such an eye is constant and eventually brings on the usual signs of exhaustion, spasm of the accommodation, headache, blur, inability to use the eyes, etc. This is corrected by a convex lens.

There is one other interesting point to make here. There is a certain relation between the effort of accommodation and convergence of the eyes. The greater the effort to focus the eyes the

greater is the effort at convergence. This action is automatic and proceeds from and is controlled by nerve centers in the brain. If these relations are harmonious and well balanced, vision and accommodation proceed without undue strain, but if either is out of harmony with the other most disastrous nervous disturbances result. This is a fertile and interesting field of study and practice for the neurologist and ophthalmologist.

As one grows older the tissues become firmer and less elastic. This is true of the eye and results in hardening of the fluid lens, making it less elastic and more resistant to changes of curvature and at the same time the ciliary muscle is less able to influence the curvature of the lens. As the result of these two changes the accommodation for near vision becomes impaired and only by holding the object at a more remote distance can small objects be seen clearly and soon even that power is lost. A convex glass converges the rays of light and brings the focus to the retina—the thing which the unaided eye can no longer do. This failure generally begins at about forty-two years of age and becomes well marked at forty-five.

Near-sightedness is the condition in which the focus is in front of the retina. There is no relief by an accommodative effort because such effort would bring the image still further forward and aggravate the condition. As the result of nonuse of the ciliary muscle it becomes weak and atrophied and the retina enfeebled. Such conditions tend to become more aggravated with time and neglect, and often almost total destruction of vision ensues. A concave glass corrects this condition.

The first recorded case of astigmatism dates from the year 1801. This term simply means that the curvature of the eye in one meridian is not the same as in other meridians, and while lines in one direction are well focused those in another direction are not so clearly focused, or, to state it in another way, the curve of the cornea is not a perfect spherical segment but somewhat flattened from opposite sides, or to speak more mathematically and exactly, its surface will not present that of a perfect surface of revolution, but that of a triaxial ellipsoid. This condition is most prolific of reflex disorders of all kinds and of severe character. Headaches, neuralgias, congestions, indigestion, confusion of mind, and a long train of symptoms are associated with this error. It is easy to see how difficult and well-nigh impossible it must be for the ciliary muscle to in any way correct this irregular and ill-balanced distortion of the cornea, and how exhausting such at-

tempt must be. This error is largely located in the cornea—though not always nor entirely so. It may be caused by faulty development of the cornea or lens, by the unequal pressure of the lids upon the cornea, by the undue tension of the muscles which move the eye in its socket, or by irregularities in the bony walls of the orbit. It may be corrected by cylindrical lenses.

The muscles which move the eyeball are mostly arranged in antagonistic pairs and on opposite sides of the ball, the contraction of one muscle and the relaxation of its opposite moving the eye in the corresponding direction. If these are not well balanced or improperly attached to the eyeball this fault gives rise to a characteristic train of symptoms, like dizziness, nausea, pain in the back of the head, congestion at the base of the brain, etc. This error is corrected by prismatic lenses.

While each of these conditions, taken separately, seems to be amenable to correction, yet such is not always the case. They seldom come singly but usually several of them are combined in the same eye and often different complications in the separate eyes, so that the proper correction and balance of forces is far from easy and calls for considerable judgment and experience. The disturbance of nerve functions and perversion of sensibility associated with these errors often demand considerable insight into both the physiology and psychology of our patient.

Fortunately we have many instruments of precision to aid us in diagnosis. The use of the test lens and test cards are familiar to all. Of the test lens I have already spoken. The test card deserves some mention. It is the result of much study and experiment. The basis of the system is as follows: The average retina can distinguish distinctly a space which subtends an angle, at the retina, of one minute. If we take five such spaces in each direction and outline our standard test-letter within that square and with each line of the letter one space wide we shall have a figure each part of which will form an image upon the retina which will subtend an angle of one minute, which is as small as the majority of eyes can see. The distance for which such a standard letter is constructed is twenty feet, that being the distance at which lines of light are practically parallel, so far as the eye is concerned. For a greater distance a larger letter must be made and for a shorter distance a smaller letter. Hence the series upon test cards. If the twenty foot letter is seen at twenty feet the vision is said to be 20/20, the numerator being the distance at which the letter is seen and the denominator indicating the size

of letter that is distinguished. If the forty-foot letter is the smallest that can be seen at twenty feet the vision is said to be 20/40, and so on. The opinion of the patient as to how well he can see and which lens gives the best vision is of value in proportion to the patient's perceptive powers, his habits of observation and comparison, his general intelligence and efforts at co-operation. But the results vary so much and are liable to so many errors, both of observation and judgment, that the examiner always distrusts his results obtained in this way and welcomes any device that eliminates the personal element from his work.

Perhaps the simplest and most reliable of these is the retinoscope and the method of determining the refraction with this instrument is called retinoscopy or studying the reflection of light as thrown back from the retina of the patient. If a pencil of light is thrown into a perfectly refracting eye the light will be focused upon the retina and reflected back through the pupil, after passing through the various refracting media twice, in the same direction and in the same parallel condition as it entered the eye. If the eye of the observer be placed in the course of such reflected light he will be able to see the reflected image and study any slight movement he may impart to the entering rays as the light is reflected. The principle involved is that if the refracting media of the eye are so perfect as to converge the parallel entering rays and brings them to a focus upon the retina, the same rays reflected from the retina and passing through the same media in reverse order, will emerge from the eye parallel, as they entered. But if the refracting media of the eye do not focus the light perfectly, then the emerging rays will not be parallel and will not respond to the experimental movements of the rays and the variations will be interpreted by the examiner to indicate certain errors. When a lens has been placed in position in front of the eye, of such strength as to correct the observed errors, the reflected light will become parallel and so inform the observer. It is evident that this added lens will be the correction for the refractive errors of the eye. By this method the examiner can rely upon the infallible laws of light for his diagnosis instead of the fallible and uncertain observation and opinion of himself and his patient.

Another valuable aid is the ophthalmoscope, which enables the physician to see the retina, directly and clearly, and at the same time note the strength of lens needed in order to get the most perfect focus upon the retina. This lens is the measure of the error

of the eyes of both the observer and the observed. By subtracting the known error of the examiner the remainder is approximately the correction sought. Not only does this instrument help in determining the refraction, but enables the physician to actually see and examine in detail every part of the internal eye, the retina, the choroid, the vitreous, the lens, the iris, the aqueous, the cornea, and the optic nerve. The principle is simply to reflect light into the eye and, through a hole in the reflecting mirror, to look into the illuminated eye.

The ophthalmometer is an instrument used to measure the curvature of the cornea, and as most of the astigmatism lies in that tissue this instrument becomes of value in that condition. The instrument is complicated but the essential principle is simple. Two illuminated objects are placed before the eye and the light from each falls upon the surface of the cornea and is reflected forward to the observer, and the distance between the images is carefully measured. In point of fact, the objects are brought near enough to each other for the images to be in contact. Then the objects are revolved into a position at right angles to their former position and their distance apart is noted. If the cornea presents a perfect curve the distance between the images will remain as before. The difference in their distance in the different positions gives the data for computation of the curve of the cornea in its different meridians, and by repeating the observations it is not difficult to determine the meridian of greatest curvature and the meridian of least curvature. This will give the axis of the astigmatism and its amount. If the astigmatism were all in the cornea this would be absolute, but unfortunately for the usefulness of the instrument, the other media, especially the lens, may be the seat of astigmatism also, so that the ophthalmometer is of limited use only.

In describing these instruments I have eliminated many elements and modifications and have made statements which may not be absolutely accurate in order to simplify the descriptions and to emphasize the salient elements and principles of each. They all help in diagnosis but, after all, the use of common sense and experienced observation count for much in adapting theoretical findings to the alleviation of suffering. We must always recognize that we not only a delicate optical instrument with which to deal, but also a most sensitive living tissue.

AN INEXPENSIVE ATWOOD MACHINE.

By Philo F. Hammond,
High School, Snohomish, Wash.

In a teachers' class at a summer school at the University of Washington an attempt was made to work out some form of an efficient, yet inexpensive, acceleration apparatus. An ordinary rigid inclined plane was found to have too much friction to give good results. The friction can be reduced to a minimum by using pulleys running over wires, but it is almost impossible to prevent the wires from sagging, which makes the angle of the incline greater near the top and this causes the results to vary. Forms of machines depending upon the ear are unsatisfactory. Other forms depending upon electrical device are efficient, but too expensive for small high schools.

The machine here described has been worked out in this laboratory as a result of the thought given to the problem at that time, and we have used it for the last two years.

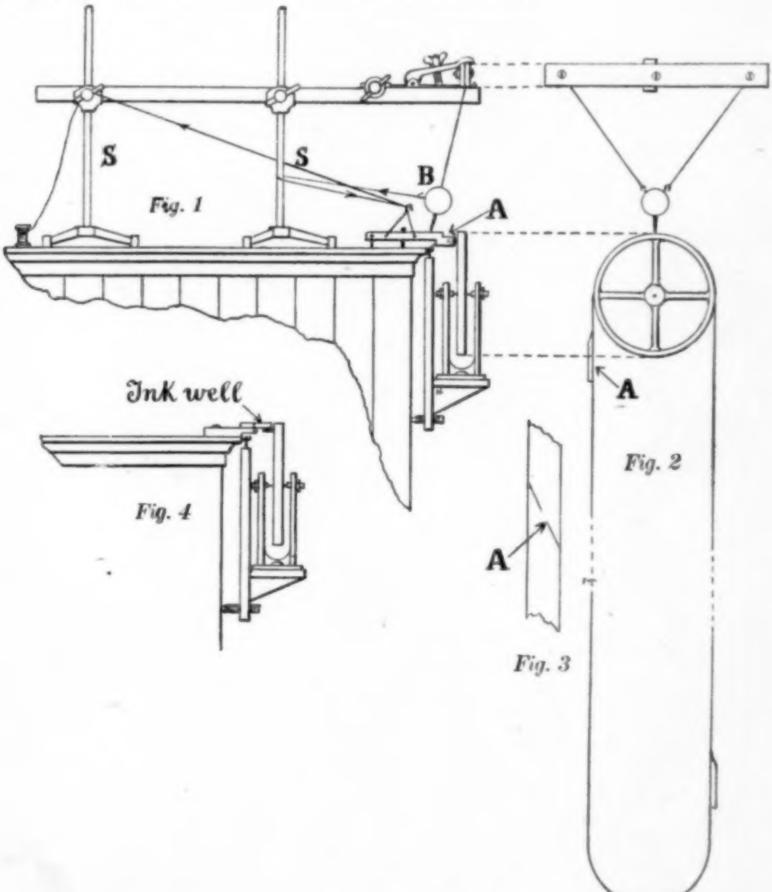
I am of the opinion that by making the apparatus on a larger scale a bicycle wheel could be used, if care enough were taken to balance and adjust it so that it would run true. This would make the cost very small and the whole machine could be made in the laboratory.

An aluminum wheel (Fig. 1) about 20 cm. in diameter and having a flat face one cm. wide, suitable for a paper belt, was purchased of one of the laboratory supply houses whose advertisement appears in this Journal. This, together with the iron frame in which it was hung, cost us $4.75. This expense covered practically the total cash cost of the apparatus.

This wheel is very light, it is perfectly balanced, and having cone bearings, it runs with the smallest possible friction. The iron frame in which the wheel runs was mounted upon a maple support made from a board taken from an old coefficient of expansion apparatus. Two screw eyes were screwed into the upper end of the support, which hooked into two hooks screwed into the moulding at the top of an apparatus cupboard. At the lower end of this support a wooden screw served to adjust the support so that the wheel would stand vertically.

An oak stick 3 cm. x 3 cm. and about 65 cm. long was clamped to two iron stands (S-S, Fig. 1) to support a pendulum which hung directly over the top of the wheel in such a way as to vibrate at right angles to the direction the wheel rotates. This pendulum

was made by drilling two holes into a large iron ball about 45 degrees apart, into which two screw eyes were securely fastened. From these two screw eyes, the pendulum was suspended by two piano wires clamped between two iron plates 35 cm. long and held together by means of three stove bolts. These iron plates were supported at their centers across the end of the oak stick mentioned above, and held into position by an iron clamp. By using two piano wires in this way, the pendulum can vibrate in only one plane. This is absolutely necessary.



Into a hole drilled into the ball on the side next to the stands, a hook was fastened for tying the end of a thread (Fig 1, B) the use of which is explained below. On the under part of the ball and directly over the wheel, another hole was drilled to carry a camel's hair brush.

A thin oak stick, shaped as given in Fig. 1-A, was fastened to the top of the cupboard by means of a nail with its end bent so that the stick could move upon the nail as a hinge. Another nail, with its upper end bent over the stick, prevented the stick from lifting too high. A wire was fastened into two holes in this stick and a hook made on the upper part as shown in the cut. This stick we will call the "stop." It prevents the rotation of the wheel, by coming in contact with a projecting rod on the side of the wheel, when it is raised as far as the bent nail will allow it to go.

Just to the left of the "stop" and directly in line with the pendulum, an ink well (Fig. 4) was placed, as close to the wheel as possible without interfering with the wheel or belt. This was made by cutting a small cavity in the side of a cork which was wired to a strip split from the lid of a crayon box. The ink-well was set slightly higher than the wheel and so adjusted that the camel's hair brush passed through the ink and marked the paper belt as it passed over it. The hairs on the brush were trimmed so that they came to a point.

To operate the machine, the ends of two strips of light pliable paper 230 cm. long and one cm. wide are pasted to two small envelopes so as to form a continuous belt. This belt is hung over the wheel so that one envelope is near the top of the wheel (Fig. 2). A few drops of ink are then put into the ink-well by means of a medicine dropper. The brush in the pendulum is then adjusted so that it will mark on the paper with the least friction possible. A loop in the end of the thread is attached to the hook on the pendulum bob (Fig. 1-B). From this hook the thread is passed around the standard, clockwise to the hook on the stop and back to the second standard where it is fastened. A fifty gram weight is placed in each envelope and in the envelope at the top a two or three gram "overweight" is placed. The wheel is then held in position and the pendulum allowed to pass across the belt to mark the starting point.

When all is ready the thread is burned off near the hook on the pendulum bob. This releases both pendulum and stop simultaneously. As the wheel rotates, the camel's hair brush marks off spaces covered in equal intervals of time on the paper belt. When the weight nears the floor, the wheel is stopped, and the belt removed and reversed from right to left in such a way that the envelope carrying the overweight will be on the same side of the wheel as at first, and the operation repeated so as to use the un-

marked side of the paper belt. Then the belt is removed and separated from the envelopes.

Measurements are then taken from the starting point to each diagonal line, care being taken to measure to the centers of the diagonal lines (Fig. 3-A). The measurements are first taken from the starting point to diagonals passing across in one direction, *i. e.*, those made by the pendulum when moving in the same direction; then from the starting point to the diagonals passing across in the other direction. This is done to eliminate any error due to the pendulum not being adjusted directly over the center of the wheel. The pendulum is a half seconds pendulum; and by measuring in this way, the time unit is a whole second.

Since the pendulum starts from its position when drawn from the center, the time from starting to the first diagonal is one fourth of a second and to the second diagonal three fourths of a second. This makes the numbers, representing the total time from the time of starting, end in fourths of seconds. This is not a serious difficulty, however, although it makes a little more work in computing the total space covered.

I have found that it saves time to have a set of belts already made for each member of the class. Then let the class see the machine in operation giving such explanations as are necessary, after which all the members of the class take measurements from the belts distributed among them.

I am quite sure that this apparatus could be used to prove $f = ma$ similar to the exercise described in the January number

DATA TAKEN BY A. C. SHADINGER AND NEWELL FOWLER.

Time T	Total distance from starting point S	Distance covered each unit of time S'	Acceleration A	Total space computed	Error	Velocity	Greatest variation from mean acc.	Per cent variation from mean acceleration
sec.	cm.	CM.	CM.	cm.	cm.	cm.	cm.	cm.
$\frac{1}{4}$	0.3			0.33	0.03	2.64		
$1\frac{1}{4}$	8.5	8.2		8.26	0.24	13.22		
$2\frac{1}{4}$	27.3	18.8	10.6	26.7	0.6	23.80		
$3\frac{1}{4}$	56.8	29.5	10.7	55.8	1.0	34.38		
$4\frac{1}{4}$	96.9	40.1	10.6	95.5	1.4	42.97		
$5\frac{1}{4}$	147.5	50.6	10.5	145.7	1.8	55.55		
$6\frac{1}{4}$	208.5	61.0	10.4	206.6	1.9	66.13		
$\frac{3}{4}$	3.1			2.9	0.2	7.94		
$1\frac{3}{4}$	16.5	13.4		16.1	0.4	18.52		
$2\frac{3}{4}$	40.7	24.2	10.8	40.0	0.7	29.10	0.22	2%
$3\frac{3}{4}$	75.4	34.7	10.5	74.3	1.1	39.68		
$4\frac{3}{4}$	120.5	45.1	10.4	119.3	1.2	50.25		
$5\frac{3}{4}$	176.3	55.8	10.7	174.8	1.5	60.83		

Mean acceleration 10.58

of School Science and Mathematics, but I have not used it for that purpose.

While this machine does not "work better in practice than it does in theory" it is a very efficient piece of apparatus and no instructor of physics need be without it for lack of funds. The errors usually range from one to four per cent.

Questions—(*To be answered by the students*).

(1) What principle is illustrated by the diagonal lines on the paper belt?

(2) Why do the lines get longer as the space increases?

(3) Does the amplitude of the pendulum have anything to do with the size of the angles these lines make with the paper? If so, explain.

(4) Why is the acceleration not 980 cm. per sec. per sec.?

(5) Give all possible sources of error.

VOCATIONAL TRAINING NOT OPPOSED TO CULTURE.

It seems evident that we must infuse into our system of public education a vocational training that, by correlation with other studies, shall the better fulfill its function. The old idea that vocational education is somehow opposed to culture should be done away with. The so-called cultural studies, frequently forced upon the uninterested pupil, contribute little or nothing to his mental growth. But a group of studies related to and grouped around a central vocational aim may, by fully arousing the interest, lead to the pursuit of a wider knowledge. But, even if this were not so, the first aim of our schools should be to fit our boys and girls for life—in other words, to give them some special knowledge by which they can make a living.

But following this first and indispensable step must come the opportunity for further education for our workers, both young and old. Public continuation schools, free lectures, social centers—all must give to the individual the special training he requires, either along vocational or purely cultural lines. And the better the workman, the more likely is he to broaden his horizon. "What is the most pressing need in legislation?" says Canon Barnett, the founder of Toynbee Hall. "It is that a way may be opened for an alliance between knowledge and industry, between the universities and the labor party. It is a sign of the times that the trade unions send relays of men to study at Ruskin College in Oxford, and that an association of trade unionists and coöperators has been formed for the higher education of workingmen." It is quite as important for America as for England to build upon the vocations this broader outlook for the wage-earner; for not until public education meets the widest needs of all the people can it be said to be truly democratic.—*American Review of Reviews.*

THE OPPORTUNITY NOW BEFORE TEACHERS OF PHYSICS.

By J. M. Jameson,
Pratt Institute.

(*Continued from the April number.*)

The March article of this series discussed several simple exercises by which the student may be led to apply the principle of the parallelogram of forces. In all of these, the point of concurrence of the forces is clearly evident. The study should not cease, however, until instances in which the forces are applied at different points on a body have been considered, and especially one in which three forces only are acting. The fact that the action lines of these three forces, when not parallel, *must* pass through a common point to produce equilibrium should be made clear. An excellent example for this is provided by the simple apparatus of a heavy bar suspended by two converging or diverging cords as in the common method of hanging a picture. With this, the student may be made to appreciate that the center of gravity of the bar will always lie in the vertical line through the point of intersection of the direction lines of the cords, no matter in what position the bar is hung, and that the diagonal of the parallelogram formed on any two of the three forces (the tensions in the cords and the weight of the bar) represents a force equal and opposite to the third force. The tensions in the cords may be measured and the weight of the bar then solved for, or the weight of the bar may be assumed and the two tensions then found, as preferred. The solution may be checked in either case from the readings of spring balances inserted in the cords or from the weight of the bar. Light balances which do not sag the cords, such as Chatillon's tubular, Sportsman's balances, will be found most satisfactory for measuring the tension in all such cases.

A bent arm lever such as used with the old-fashioned door bell pulls or in operating railway switches and semaphores, provides another excellent illustration. The point of intersection of the two forces applied to the arms may here be determined, and demonstration may then be made of the fact that the reaction furnished by the pin about which the lever turns also passes through this point, and that the value of the reaction is equal and opposite to the diagonal of the force parallelogram drawn to scale on the two forces. The value and direction of the pin reaction may be found from the value and direction of the pull which will hold

the lever in position when the pin is removed. This conception of a pin or a hinge as furnishing a reaction of a definite amount and in a definite direction is an important one in applied mechanics.

Group III. Moment of Force.

Probably no one idea is of greater importance in statics and in applied mechanics in general than that of the moment of a force with respect to a given axis. The usual elementary exercises on levers, where the forces are always applied at right angles to the bar, do not develop this idea with sufficient definiteness. Such exercises fail to bring out the conception of the moment arm as the *perpendicular* distance from the axis to the action line of the force, and to show the usefulness of the principle of moments in cases of oblique as well as of parallel forces. The following are suggested as simple problems introducing the idea of moment of force in a practical and general sense:

(a) The Steelyard.

An ordinary steelyard from which the graduation notches have been removed with a file provides a most excellent piece of apparatus for the elementary laboratory. Two or three sliding weights of different sizes should be provided with each bar so that different conditions for balance may be arranged with the same piece. The student may first find the center of gravity and weight of the steelyard bar alone, and the weight of his slider. From these and the distance from the supporting hook to the center of gravity, he may be required:

(A) To find the "zero" of the apparatus; *i. e.*, where the sliding weight must be hung to balance the unloaded steelyard.

(B) The length of 1 lb., 2 lb., etc., "notches" on the bar.

(C) The weight of an unknown heavy body by means of the apparatus he has thus graduated.

All these are direct problems in moments and all may be checked by trial with corresponding known weights.

(b) The Center of Gravity of a Surface.

In addition to the importance of being able to locate the gravity axis of a section in applied mechanics and in the study of the strength of materials, this problem has a high value as a simple and direct exercise in moments. The apparatus required is the simplest, consisting only of cardboard of uniform thickness, cross section paper, ruler and divides. Surfaces bounded by straight or by curved lines may be assigned—preferably one of each sort. Standard sections for I beams, angles, etc., should be selected

when possible. The student should be required first to lay out his figure to scale upon the cardboard. This figure is then to be cut out neatly and accurately and outlined upon a sheet of cross section paper by placing it upon the cross section paper and passing a pencil around the edge. The computation for the center of gravity of the figure by the usual two equations referred to two axes at right angles is then to be made, the dimensions, distances from the axis, etc., being taken directly from the cross section paper as required. Finally, the solution is to be checked by suspending the card from two points and thus locating the center of gravity experimentally.

(c) THE LADDER PROBLEM.

This problem never fails to arouse interest provided a *real ladder* (at least eight or ten feet long) and loads of a hundred pounds or more are used. The arrangement of apparatus is shown in Fig. 11. The center of gravity and weight of the ladder must be known. These and the amount and position of the load placed on the ladder, together with angles, distances, etc., which may be measured on the apparatus as required, constitute the known data. The problem is then to determine the horizontal reaction at the top of the ladder, and the vertical and horizontal ground reaction at the foot. The equation of moments about an axis through the point of application of the reactions at the foot of the ladder may be solved to find the horizontal reaction at the top. A similar equation about the axis through the point at which the direction lines of the horizontal reaction at the top and the vertical reaction at the foot intersect gives the horizontal reaction at the foot, and a third moment equation about an axis at the top of the ladder now gives the vertical ground reaction at the foot. These equations furnish most valuable ideas about the moment arms, axes of moments, and moment equations for a member of a structure when in equilibrium.

Or if preferred, the apparatus may be used as a simple illustration of the general conditions for equilibrium:

(1) Sum X Components = zero.

(2) Sum Y Components = zero.

(3) Sum moments = zero.

Equation (3) having been solved for an axis at the foot of the ladder, the values for equations (1) and (2) may be found by substitution. The solution is to be checked in either case by the balance readings in the horizontal cords at the top and foot of the ladder, and from the weight on the platform scale upon which

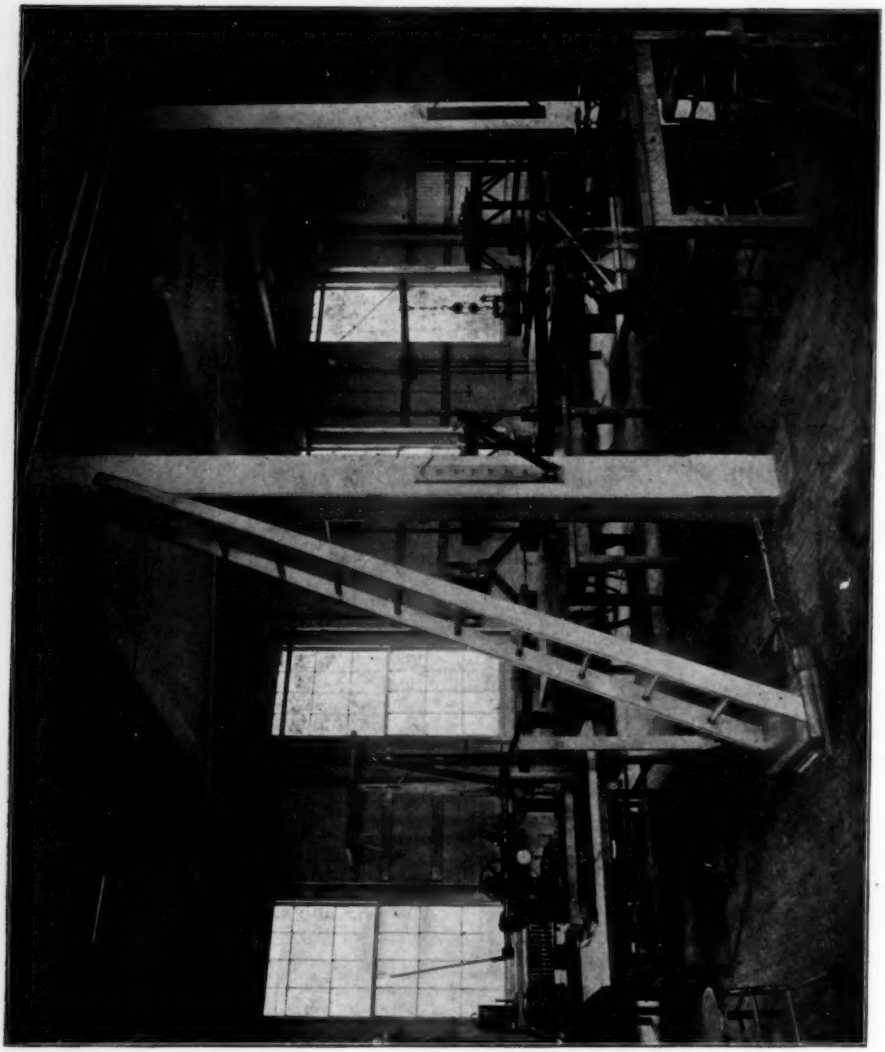


FIG. 11. FORCES ON A LADDER.

the ladder rests. The play allowed by the platform of the scale will usually be sufficient to permit of judgment as to when the horizontal thrust at the foot is taken by the cord; in cases where it is not, the ladder may be put on freely moving casters. Readings of the balances in the cords and of the weight on the scale must be taken when the ladder is held "floating," *i. e.*, free at the top. If it is desired to include a force at the top such as would be given by the friction of the ladder against the side of a build-

ing, etc., a vertical cord may be attached at the top and any desired vertical force thus applied.

(d) THE ARCH:

The arch shown in Fig. 12 furnishes an exercise in moments similar to the ladder problem and may be used as an alternative for it. A second application of the same principles of mechanics is thus available, and a larger number of students may be provided with an exercise of the same character without duplication of apparatus. The weights of the two halves of the arch, which is made in two pieces, and the applied loads are to be taken as the known forces, from which together with the necessary distances, etc., measured on the model, the reactions at the supports and the compression at the center of the arch ring are to be found. One end of the arch should be held by a pin through the frame to give stability, the other end should be "floated" by cords as in the figure. The balances in these cords measure the vertical and horizontal reactions at the support. The compression at the middle of the arch ring where the two halves join may be measured by a compression

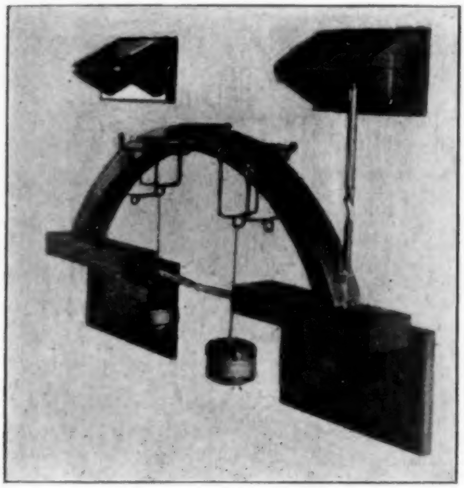


FIG. 12. THE ARCH.

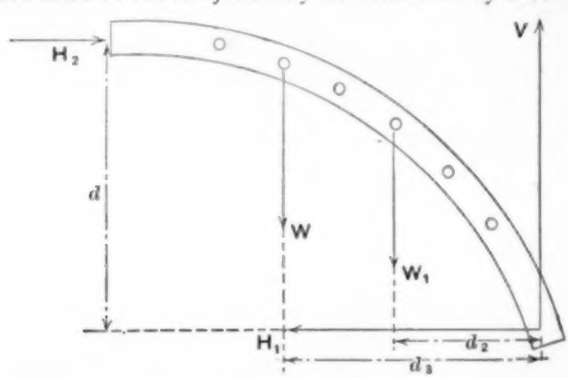


FIG. 13. FORCES ON A HALF ARCH.

balance or by attaching balances and pulling horizontally in opposite directions until the halves are separated. The solution of the problem will be obvious from the diagram of the forces on a half arch given in Fig. 13, and the suggestions for the moment equations given for the similar problem with the ladder. A suggestive variation in the exercise may be made by loading the two halves differently and noting, through "floating" first one end and then the other, that under such conditions the horizontal reactions at the ends are equal, while the vertical reactions are different.

(e) THE WALL CRANE.

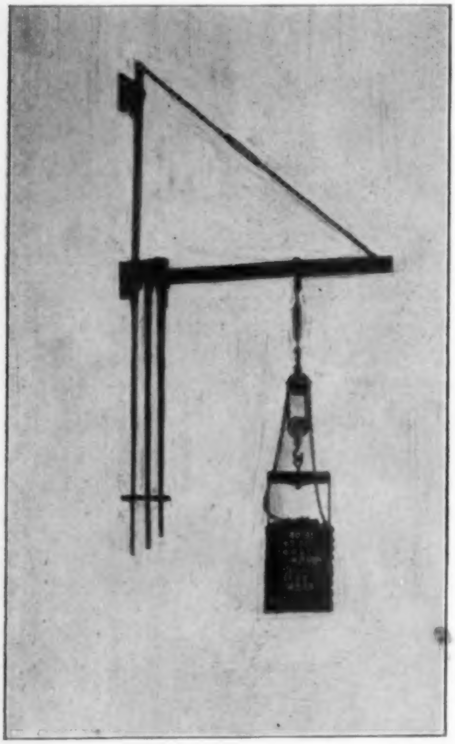


FIG. 14. THE WALL CRANE.

A somewhat elaborate but very satisfactory form of this apparatus with which large loads may be used is shown in Fig. 14. The tension in the tie rod and the vertical and horizontal reactions at the pin by which the horizontal arm is attached to the support at the wall are here measured for any given amount and arrangement of load by means of balance pulls applied to levers of previously determined multiplying power. An equally satisfactory and very simple form for small loads may be arranged from the small wall truss shown in Figs. 1 and 3 (see the March issue of this journal). The light rod of that apparatus should be replaced, for the purposes of this exercise, by a rod of rectangular section having sufficient depth to resist bending. The slot in the end of this rod at the wall should be so constructed as to permit of its being freed from the pin both *horizontally* and *vertically*, as the pin must now supply a reaction

in both directions, the resultant of which does not lie along the axis of the stick. The forces producing equilibrium are now as shown in Fig. 15. W and L are known in amount and position and T, H, and V are to be determined from the conditions of the problem. The horizontal component of the pin reaction, H, may be checked by a horizontal pull applied at the outer end of the rod as for the exercise on the stick and tie, the vertical reaction, V, by the pull in a third vertical cord attached to the end of the rod next the wall required to free the end from the pin.

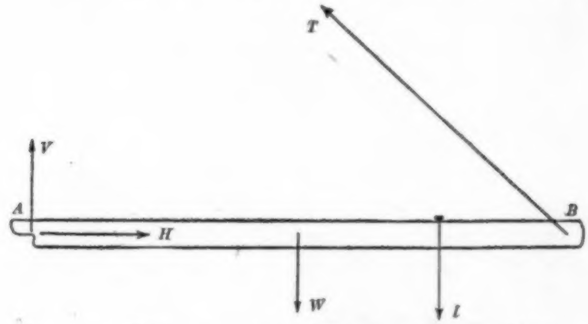


FIG. 15. FORCES ON THE JIB OF A WALL CRANE.

With this apparatus which is a practical model of a common wall or post crane, the student may determine the tension in the tie and the components of the reaction furnished by the pin supporting the end of the horizontal arm at the wall due to any given load, and may note the dependence of these forces upon: (a) the angle which the tie makes with the arm; (b) the amount of the load and the distance from the wall at which it is applied.

GROUP IV. THE USE OF MODELS OF COMMERCIAL STRUCTURES AS LABORATORY APPARATUS.

The arch and wall crane of Group III may very properly be regarded as coming under this heading of "models" to be used in teaching mechanics. The writer's only excuse for classifying them as exercises in moments is the desire to emphasize the importance of the idea of moment of force and to illustrate the very common application of the principle in determining the forces in the members of familiar structures. The selection of this fourth classification is equally frankly a means to the much desired end of bringing sharply to the attention of physics teachers the issue of applied physics as contrasted with purely scientific or historical physics, and of arousing a fuller consideration of what is really

involved in the problem of so-called "applications of physics." That we should make some application of our physics teaching to everyday life, I imagine every physics teacher will agree. But what applications and, especially, *how?* A few scattering "applications" dragged in *after* the whole subject has been developed in a purely abstract, book way, in a schoolroom atmosphere and by schoolroom methods, both absolutely distinct from those which will obtain as soon as the pupil gets outside the school, in my judgment, will never secure for physics *real* results. Our teaching ought to be *through* the applications, through the pupil's own experience and observation, and our laboratories ought to be filled with the common objects of everyday life, reproducing as fully as possible actual conditions. And of no part of physics should this be more true than of mechanics which is so essentially a usable subject. The pupil who knows the principles of mechanics in their "word forms" only has no real knowledge of mechanics. And how are we to teach real mechanics except as we deal with real things? This is the fundamental problem that the teacher of physics must face, and it is as a suggestion for the solution of this problem that I am urging the use of models in teaching mechanics. Such models are not limited to statics, but that is the part of mechanics that happens now to be under consideration. Several of these "models" have been mentioned. Other teachers have developed many different and better ones. Let us get them all together and before physics teachers for their consideration. And before I call my part in this work of publicity finished (or just started as you prefer), I wish to mention two other pieces that have been tried thoroughly

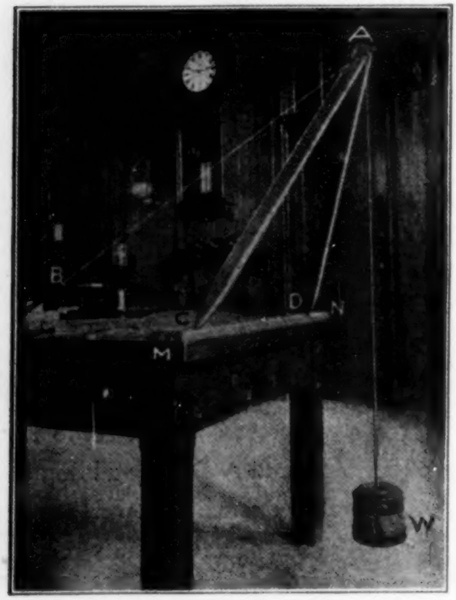


FIG. 16. LABORATORY MODEL OF A SHEAR LEGS.

and found most satisfactory.

(a) THE SHEAR LEGS.

This model as shown in Fig. 16 may be made from tubing or from wood as preferred. In the one here shown the legs are about 4 feet long, of 1½ inch oak. The "feet" are tapered and set in holes in the board MN which is screwed fast to the table. Several quick adjustments of the "spread" are thus possible. The legs are joined at A by a hinge, the pin of which passes through a clevis. By fastening a balance to the clevis and pulling up, along the line of a leg, until the foot just clears the support, the thrust at foot of the leg may be determined. The tie is of braided wire and, by an easy adjustment of its length, the legs can be inclined at any angle to the vertical. A spring balance placed in the tie registers the tension in that member.

The method of solution usually followed is as follows: About a 20 pound load is hung at W. The legs together weigh 2 pounds, and as one half of this may be considered as acting at A and the other half at the feet, one pound is added to the weight W, in all computations.

The thrusts in the legs may be imagined to be taken up by a single member in the plane of AB and AW, running from R to A (See Force Diagram, Fig. 17). We now have a simple case of equilibrium produced by three forces meeting at a common point. The stresses in tie AB and imaginary leg AR, are now found graphically or by trigonometry. Using the same methods, the force AR is then resolved into its two components along the legs, AC and AD. By adding to these values .7 pound (the effect of the remaining weight of the leg), the thrust at the foot is found. These results are then compared with the test readings taken as described.

Below is a copy of the results obtained by two students:

EXPERIMENT NO. 14-2. THE SHEARS.

A known weight, W, was hung on the model, and the angles between the different members measured. The compression in the legs and the tension in the tie (AB) were then computed by the following method, and the results obtained checked by reading the balances placed in the line of tie and legs.

DATA.

W	18.4 Pounds
Weight of AC	1 Pound
Weight of AD	1 Pound
Angle, WAB	67 Degrees
Angle, WAR	25 Degrees
Angle, CAR	31 Degrees
Angle, DAR	31 Degrees

Method of solution:

By Fig. 17, it is seen that forces AD and AC may be replaced by a single force AR, which will be their resultant. Using this resultant together with forces AB and AW, a force diagram, Fig. 18, of the point A was drawn in which AW represented the known weight W; AB the tension in tie; AR, the resultant of the thrusts in legs AD and AC.

Note.—One half the combined weight of legs AB and AC is considered as acting at A, the other half at B and C.

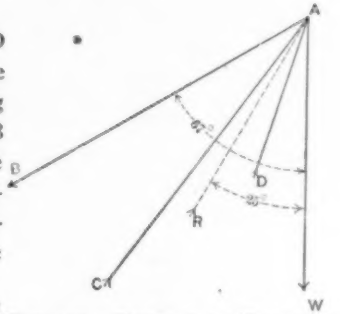


FIG. 17. FORCES AT POINT A OF THE SHEARS.

(a) to solve for forces AB and AR, a force parallelogram as shown in Fig. 18 was drawn. From this, Force AR equals 26.7 lbs., force AB equals 12.3 lbs.

The balance placed in the tie AB read 12.2 lbs., therefore the computed value differs about 17. from the experimental value.

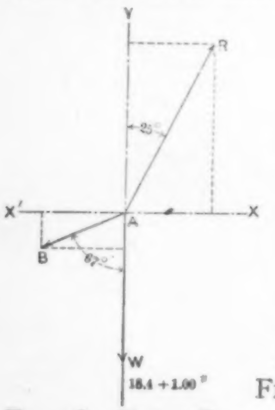


FIG. 18. FORCE DIAGRAM.

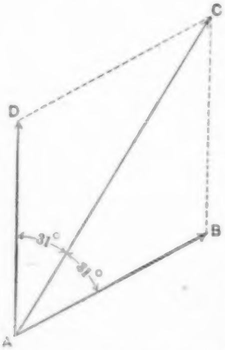


FIG. 19. FORCES FOR THE SHEAR IN THE LEGS.

(b) to find compression in the legs AD and AC:

The force AR was then resolved graphically into its components along the legs AC and AD as shown in Fig. 19. From this diagram, compression in AC equals compression in AD equals 15.5 lbs. Adding .7 lb as a correction for the weight of the stick as before stated, we have 15.5 plus .7 equals 16.2 lbs. as the thrust along the axis of each leg at C and D. The check reading of the balance when a pull in the axis of the stick which must be exerted at A to free the foot at D from the base was 16.3 lbs.

B. THE CRANE WITH GUY ROPES.

The construction of this model is shown in Fig. 20. The parts are large enough to permit the application of a heavy load to the crane, and also to require a definite correction for the weight of the parts. A pin in the top of the mast is held by a ring of considerably larger diameter than the pin when the guy ropes are free from tension. When the crane is held by the guys, this pin is free at the center of the ring. The foot of the mast is carried on steel balls to give free horizontal

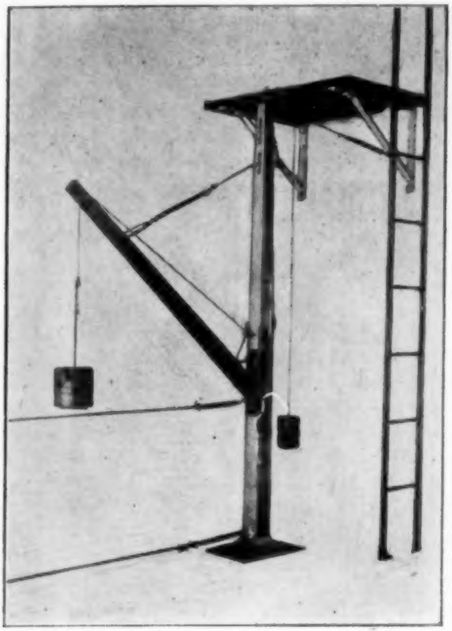


FIG. 20. THE CRANE WITH GUY ROPES.

play within fixed limits and thus permit the horizontal reaction at the foot to be measured. For the vertical reaction, the whole crane may be placed on a platform scale. The joint by which the jib is attached to the mast consists of a steel pin fastened to the jib and passing through slots in side plates screwed to the mast. The vertical reaction at the foot of the jib is measured by two spring balances, one on each side of the mast, and the horizontal reaction is checked by pulling horizontally until the pin is free in the slots. The character of the laboratory exercise, work to be done by the pupil, etc., is shown in the following direction sheet:

EXPERIMENT 14-5. THE FORCES IN THE MEMBERS AND GUY ROPES OF A CRANE.[1]

Apparatus in the Laboratory: Model of a crane; scale pan and weights; meter stick.

Apparatus from the Stock Room: Large Protractor.

Set up your apparatus as an ordinary hoisting crane or derrick. Attach the tie and hoisting ropes at the points designated and apply a load as directed. Shorten the guy ropes until the pin in the top of the mast is in the center of the ring.

Assume the applied load and the weights of the mast and boom as the known forces. The weights and centers of gravity for the mast and boom are marked on the sticks.

Measure any angles needed, as also any moment arms or lengths and compute:

(1) The tension in the tie.

(2) The vertical and horizontal forces exerted by the boom against the mast.

[1]From Physics Laboratory Notes, Part I. Copyrighted, 1911, by J. M. Jameson, Brooklyn, New York.

(3) The amount and direction of the total force of the boom against the mast.

(4) The tension in each guy rope.

(5) The vertical and horizontal floor reactions at the foot of the mast.

(6) The horizontal component of the forces in the guy ropes. Compare this with the horizontal reaction at the foot of the mast.

Record your data, distances, etc., on a diagram of the apparatus. Show all computations required. Make proper corrections for the weights of the mast and the boom.

Check your computed forces from the balance readings and compare the computed and check values. The check readings for the tension in the tie, and the vertical and horizontal forces of the boom against the mast are to be taken with the foot of the boom held just free from the mast by a horizontal pull with a rope and spring balance. The boom should be set vibrating slightly before taking readings to avoid friction, and several readings should be taken to get average values.

In finding the tension in the guy ropes, first assume the two guys to be replaced by an imaginary single guy in the vertical plane of the boom and mast. Compute the tension in this imaginary guy and then resolve this into its components along the actual guy ropes.

N. B. When the experiment is completed, remove the load and take the tension off all balances.

A CRY FOR HELP.

An international congress of educators and scientists should be brought together to frame national and international programs for the promotion of the hope, the health, the happiness of mankind. Professional politicians, political theorists, representatives of special interests, ignorant and intolerant reformers seeking by legislation to make wicked men angels, misguided enthusiasts and faddists with medical and social panaceas—these are they who for ages have sought and still seek to shape legislation and to make their voices heard in the councils of mankind. But a new era is dawning. Slowly but surely the demagogue, the hired attorney, the charlatan, is being relegated to the rear, and the voice of Science and the Message of Reason are being heard even in the halls of legislation and in the congresses of mankind.

A hundred and sixty million dollars for pensions for war veterans, . . . a hundred millions for battleships to defend ourselves against the far-distant Jap, and not even one million to protect ourselves against preventable diseases that sweep away annually six hundred thousands of our people! Ten million for a single Dreadnaught and nothing whatever from the national government for the training of sanitarians! Millions for the cure and prevention of disease among hogs, and horses, and chickens, and cattle, and nothing for the prevention of diseases that mercilessly destroy helpless children!

What do our readers think of this unbalanced condition? Hardly any attention given by Congress to our most valuable asset. Keep working, we will win in the end.

A DECISION.

By J. A. Randall.
Pratt Institute.

A committee on physics and one on chemistry was appointed at the Syracuse meeting of the New York State Science Teachers' Association in December, 1910, with instructions to make an organized effort to bring about some of the improvements in teaching which have been so much talked about. To be sure there were those who said, "People have been talking about education as a preparation for everyday life for fifteen years, and while the idea constitutes a nice bit of theory, nothing will come of it." The spokesman of this group made a prophecy of failure by pointing out that we have had committee after committee which would meet, deliberate, discuss, and disband in time to make way for its successor. The indifference and skepticism of some of the members has made more active the support of those who believe that there is nothing like trying.

Having embarked upon this enterprise, the call led in so many directions we were at a loss where to begin. Our teaching should build upon the experiences of the student, but since he has little suitable experience in such subjects as electricity and mechanics the function of the laboratory is to give an experience of a sort which will be valuable to him later. People mean much the same thing when they say that our physics laboratories should develop students in the same way that the chores on the farm developed some of us when we were of school age. Obviously, then, to take up first the matter of apparatus and laboratory exercises was to start at the heart of the problem.

Most experienced teachers have been thinking a great deal about the utility of the facts and principles of physics that we have been teaching. Each of us has tried out some exercises with equipment which makes the association with the corresponding operation of later life apparent. Clearly a rapid interchange of such exercises and devices as have been found successful was the first duty of the committee.

It is recognized that this is a function of our school journals but the committee has hoped to be a more personal and informal medium.

The committee has undertaken to accumulate designs of apparatus and make them available alike to teachers who desire to build apparatus in school shops and to manufacturers of school supplies. A large number of blue prints have already been sent to teachers and several makers have expressed a desire to offer for sale apparatus built from these designs. In addition the committee is trying to accumulate direction sheets for exercises using commercial articles like an arc lamp, electric cooking utensils, a steelyard and a ladder. It is desired to find out just how teachers use these and similar articles as apparatus in exercises that are not merely interesting but which give a mastery of important principles or facts and develop power by methods which may be generally followed.

No one person can be expected to contribute any large part of the designs and exercises if the work is to be representative. Accordingly at the Washington meeting of the American Federation held December 28, 1911, the request was made that a national committee be appointed to consist as far as possible of chairmen of local committees to be organized to help in this work of accumulation and distribution. As was announced in the March issue of SCHOOL SCIENCE AND MATHEMATICS a committee was appointed and has since been enlarged by the appointment of Mr. C. M. Westcott of Hollywood, Cal., and Professor F. H. Beals of Newark, N. J.

These committees have been organized in the belief that most teachers are interested in the line of improvement selected and will coöperate. WILL YOU PERSONALLY CONTRIBUTE THE DESIGNS AND EXERCISES THAT YOU HAVE ORIGINATED? The success of the work depends upon each teacher and not merely upon the efforts of the committee. Write to-day and let us know what exercises your school is using which differ from the "College Entrance Physics." Every design and exercise will bear the name of the contributor.

I have referred in the title to a decision and it is a decision which you are to make. Are you going to lend a helping hand and thereby strengthen the organized work of our profession?

There is other work that needs to be undertaken quite as much as the work in hand and if the reader is interested in seeing us get to it let him help us complete this first portion.

The following excerpts are from a circular letter issued by Mr. W. R. Pyle, chairman of the New York Physics Club Committee on Improvement in Teaching:

5. We earnestly trust that the Physics Club will do its duty, as a member of the Federation, in contributing *enthusiastically* its share of whatever is called for.

6. The chief aim is to get the Department of Education at Washington to do a work for teachers similar to that which the Department of Agriculture is now doing for farmers. A grand work is being done for farmers in several ways, one of which is the *free distribution of pamphlets dealing with farmers' problems.*

7. The United States Commissioner of Education has already signified his willingness to publish in pamphlet form the result of the work of the Federation's Committee.

8. WHAT WE WANT YOU TO GIVE US:

(a) ANYTHING—great or small—which the richness of your experience tells you may be of aid to the young or inexperienced physics teacher.

(b) Pieces of apparatus (not duplicates), full size or half-size models, that you have devised, together with instructions for use.

(c) Drawings, or blue prints, (to scale) of your simpler pieces with instructions for use. (Teachers can then construct their own pieces from your working drawings.)

(d) The Knott Company of Boston has offered to make any piece of apparatus you may suggest to the committee, send it free of charge to the N. E. A. meeting, and give you credit for same both at the N. E. A. and in their catalogues should they place same upon the market. (No royalties can be expected in such cases, of course.) One or more of the Chicago makers will probably undertake a similar work for the teachers of the Middle West.

(e) Teaching suggestions that you believe would aid young or inexperienced physics teachers. We anticipate that many of the bulletins will contain such suggestions for the inexperienced.

(f) Suggestions of things that large firms, such as the Weston, Leeds, and General Electric might begin to make for the schools; for example, instruments with *visible* movements and parts.

(g) Any information concerning new pieces of equipment recently invented.

(h) Suggestions of what things need yet to be devised to improve laboratory equipment.

You are busy and so are we; but a new and great work needs to be systematically done for physics teaching in this country. Even the little things are often very important—a good formula for a universal laboratory wax, a favorite laboratory outline, recipe for a good waterproof, transparent varnish, etc.

Give us ANYTHING and EVERYTHING.

This has called forth a generous response on the part of the club members and the large number of contributions are being arranged for publication.

Mr. J. M. Jameson has placed at the disposal of the committee all of the designs of the Department of Physics of Pratt Institute. A series of articles is now running in SCHOOL SCIENCE AND MATHEMATICS in which cuts of various pieces are shown and discussed. Working drawings for all of these may be had upon application.

The conservative element has helped us to see the difficulties of our problem by their pessimistic statements regarding the capabilities of teachers to work out the new educational ideas. One rhetorical question in particular has been asked over and over again: "How can teachers who, by experience, know nothing of the work-a-day life of the people, intelligently prepare students for their future activities?" Granting the premise there is only one answer, but many science teachers are taking active steps to see that the premise shall not apply. The male chemistry teachers, in the East particularly, are devoting much time to visits to factories, power plants, mills, and other industrial works. While this does not result in anything more than a spectator's knowledge of industrial and commercial life, it is indicative of the consideration which many teachers are devoting to the problem of giving instruction with due regard to the physical, vocational, and cultural needs of the student.

Physics teachers cannot ignore the fact that the products of engineering are in the hands of everyone, that the need of greater understanding of the principles of machinery, manufacturing, and the economic use of labor is gaining very fast, and that the number of applications of the simple physical principles and facts has multiplied beyond the capacity of any one teacher to observe or comprehend. We must depend upon one another. By adding to our own observations the results of the inspection of teachers in every type of neighborhood in the land we must form a composite conception of what conditions our students must meet. We may then take steps to prepare them to meet average conditions. The committee has hoped that its plan of circulating exercises and apparatus designs would make available the experience of other teachers in a very practical way.

We have passed the period when we can turn over the development of physics instruction to any one authority. Our pessimistic colleagues have questioned the wisdom of the leadership of college men and of the state authorities. They have succeeded in convincing us that many teachers have been blindly following successful men. The college man is not the only "big fellow" who has stood up and said, "Now let me tell you how I do it." We have been developing other criteria of what constitutes sound educational work than that a successful teacher has used the device or exercise. It has

been generally true that the successful teacher has had a strong personality. Such a teacher has often succeeded in spite of faulty methods and equipment, through the sheer force of his personality.

We are coming to believe that each teacher should develop his own outline. In every class in which elementary physics is taught there is a variation in type of student with requirements which cannot be satisfied by a formal course developed under other conditions. For example, the physics and chemistry needed for girl students of household science and arts have been independently developed by a number of teachers. None of these courses are alike but all are better adapted to their purpose than the college entrance requirements.

We have come to the time when all science teachers should become closely allied with a single national organization which shall serve our profession as the American Society of Mechanical Engineers serves its clientele. In the past we have been too busy with personal issues. We have yet to develop a strong national organization—with a progressive and continuous policy, with machinery for keeping abreast of the changing conditions, with officers chosen for their capacity and willingness to serve and with a dignity worthy of our high calling.

The committee asks *you* to come to the *decision* that you will support it, and help in its labors because you believe in supporting the organized work of your profession. Decide to help shape it, for by our works shall our profession be known.

PROPAGATION BY ROOTS.

Ordinary roots originate from stems and not stems from roots as is popularly believed. The source of this mistake is doubtless to be found in those plants which die down to the earth, each autumn, and in spring grow again "from the roots" as common parlance has it, though the botanist knows that the new shoots really spring from underground stems and not from true roots. Although normally roots do not give rise to stems, yet species in which roots can do this are by no means rare, and in fact, so unvarying is this feature that man depends upon it for propagating several of his food plants. The sweet potato is, unlike the common white potato, a true root and is propagated by shoots that arise from it in considerable numbers; in fact, this plant seldom, if ever, produces seed, its usual means of multiplication being by means of such shoots. The yam, a tropical root, not very closely allied to the sweet potato though often confused with it, is also multiplied in this way. Among vegetables of northern gardens propagated from sections of roots capable of originating buds and shoots may be mentioned horse-radish and sea kale. The dahlia is a familiar instance among plants cultivated for ornament and others are phloxes and butterfly-weed.—*American Botanist.*

PROBLEM DEPARTMENT.

By E. L. Brown,
Principal North Side High School, Denver, Colo.

Readers of this magazine are invited to send solutions of the problems in which they are interested. Problems and solutions will be duly credited to their authors. Address all communications to E. L. Brown, 3435 Alcott Street, Denver, Colo.

Algebra.

287. *Hawkes' Advanced Algebra, p. 79, Ex. 45.*
Solve and check:

$$x^{\frac{7}{3}}+\frac{41x^{\frac{1}{3}}}{x}=\frac{97}{x^{\frac{2}{3}}}+x^{\frac{5}{6}}.$$

Solution by A. N. Meyer, Niagara Falls, Canada, and W. P. Russell, Claremont, Cal.

$$x^{\frac{7}{3}}+41x^{-\frac{2}{3}}-97x^{-\frac{2}{3}}-x^{\frac{5}{6}}=0,$$

or $x^{\frac{7}{3}}-x^{\frac{5}{6}}-56x^{-\frac{2}{3}}=0,$

or $x^{-\frac{2}{3}}(x^{\frac{1}{2}}-2)(x+2x^{\frac{1}{2}}+4)(x^{\frac{1}{2}}+7^{\frac{1}{3}})(x-7^{\frac{1}{3}}x^{\frac{1}{2}}+7^{\frac{2}{3}})=0.$

$\therefore x^{\frac{1}{2}}=2,\ -1\pm\sqrt{-3},\ -7^{\frac{1}{3}},\ 7^{\frac{1}{3}}\left(\frac{1\pm\sqrt{-3}}{2}\right).$

$\therefore x=4,\ -2\mp2\sqrt{-3},\ 7^{\frac{2}{3}},\ 7^{\frac{2}{3}}\left(\frac{-1\pm\sqrt{-3}}{2}\right),$

or $x=4,\ 4\omega,\ 4\omega^2,\ 7^{\frac{2}{3}},\ 7^{\frac{2}{3}}\omega,\ 7^{\frac{2}{3}}\omega^2$, where ω and ω^2 are the two imaginary cube roots of unity.

Check:
When $x=4,\ 4\omega,\ 4\omega^2$,

$$x^{\frac{7}{3}}+\frac{41x^{\frac{1}{3}}}{x}=\frac{x^{3}+41}{x^{\frac{2}{3}}}=\frac{64+41}{x^{\frac{2}{3}}}=\frac{105}{x^{\frac{2}{3}}},$$

$$\text{and }\frac{97}{x^{\frac{2}{3}}}+x^{\frac{5}{6}}=\frac{97+x^{\frac{3}{2}}}{x^{\frac{2}{3}}}=\frac{97+8}{x^{\frac{2}{3}}}=\frac{105}{x^{\frac{2}{3}}};$$

when $x=7^{\frac{2}{3}},\ 7^{\frac{2}{3}}\omega,\ 7^{\frac{2}{3}}\omega^2$,

$$x^{\frac{7}{3}}+\frac{41x^{\frac{1}{3}}}{x}=\frac{x^{3}+41}{x^{\frac{2}{3}}}=\frac{49+41}{x^{\frac{2}{3}}}=\frac{90}{x^{\frac{2}{3}}},$$

$$\text{and }\frac{97}{x^{\frac{2}{3}}}+x^{\frac{5}{6}}=\frac{97+x^{\frac{3}{2}}}{x^{\frac{2}{3}}}=\frac{97-7}{x^{\frac{2}{3}}}=\frac{90}{x^{\frac{2}{3}}}.$$

288. *Proposed by Nelson L. Roray, Metuchen, N. J.*
One night three men, A, B, and C, stole a bag of apples and hid them in a barn over night intending to meet in the morning to divide them equally. Some time before morning A went to the barn divided the apples into three equal shares and had one apple too many, which he threw away. A took one share and put the others back into the bag. Soon after B came and did exactly as A had done. Then came C, who repeated what A and B had done before him. In the morning the three

met saying nothing of what they had done during the night. The remaining apples were divided into three equal shares with still one apple too many. How many apples were there in the bag at the beginning?

I. *Solution by A. M. Harding, Fayetteville, Ark.*

Let t=total number of apples in the bag.

a, b, c=the number taken at night by A, B, C, respectively.

s=share of each next morning.

We then have the following equations:

$t-1=3a$, $t-2-a=3b$, $t-3-a-b=3c$, and $t-4-a-b-c=3s$.

Eliminate a, b, c and obtain $8t-81s=65$.

This equation can be written in the form

$$\left.\begin{array}{l} s = 8p - 1 \\ t = 81p - 2 \end{array}\right\} \text{ where } p \text{ is some integer.}$$

By giving p the values 1, 2, 3,........we find t equal to any term of the series 79, 160, 241,........$(79+81n)$.

II. *Solution by Norman Anning, North Bend, British Columbia.*

If there had been two more apples there would have been none to throw away. A could have taken one more and left two more than he did. Then B could have taken one more and left two more than he did. C likewise. And then there would have been one more for each of them at the last. Hence our number lacks two of being divisible by 3^4. Or $N \equiv 79$, mod. 81.

III. *Solution by the proposer.*

The number of apples left by C is evidently an even number and also a number from which when 1 is taken the difference is a multiple of 3.

This series of numbers is evidently 4, 10, 16, 22, etc.

Let x = No. of apples left by C.

Then $\frac{3}{2}x + 1$ = No. of apples left by B.

$\frac{9x+10}{4}$ = No. of apples left by A.

$\frac{27x+30}{8}$ = No. of apples, less 1, found by A.

$$\frac{27x+30}{8} = 3\left[x + \frac{x+10}{8}\right].$$

Any number of the series 4, 10, 16, 22, etc., that makes $3\left[x + \frac{x+10}{8}\right]$ integral is a solution. Evidently 22 is the least number, 46 the next, 70, etc., increasing by 24 each time.

Therefore A found 79, 160, 240, etc.

Geometry.

289. *Proposed by L. R. Perkins, Franklin, Mass.*

Without employing proportional lines, construct a triangle given: c, B, $b-a$, where $b>a$.

Solution by H. H. Seidell, St. Louis, Mo., and H. A. Morrison, College View, Neb.

Take BA = c, and at B construct $\angle$EBA = $\angle$B. Produce EB through B to D, making BD = $b - a$. Draw AD and draw the perpendicular bisector of AD meeting BE at C. Then ABC is the required triangle.

For CD = CA and $\therefore$ CD — BC = CA — BC, or BD = CA — BC and $\therefore$ $b - a$ = CA — BC.

290. *Proposed by Franklin T. Jones, Cleveland, O.*

If the edge of a regular tetrahedron is a find the radia of the inscribed and circumscribed spheres.

Solution by Irvin E. Kline, Blairstown, N. J., and G. I. Hopkins, Manchester, N. H.

Let A — BCD be the regular tetrahedron.

Draw AM $\perp$ face BDC and BP $\perp$ face ADC.

Let AM and BP intersect in O.

Draw BE $\perp$ DC and AE $\perp$ DC.

BE passes through M and AE through P.

The radius of the circum-sphere is OA and of the inscribed sphere is OM.

$\frac{PE}{AP} = \frac{PM}{AB} = \frac{OM}{OA} = \frac{1}{3}$ [from the similar triangles ABE and EMP and the similar triangles OMP and OAB].

$\therefore OM = \frac{1}{4} AM$ and $OA = \frac{3}{4} AM$.

$ME = \frac{1}{3} BE$.

$AE = BE = \frac{a}{2}\sqrt{3}$. $ME = \frac{a}{6}\sqrt{3}$.

$\therefore AM = \frac{a}{3}\sqrt{6}$, and $\therefore OA = \frac{a}{4}\sqrt{6}$ and $OM = \frac{a}{12}\sqrt{6}$,

the radius of the circum-sphere and the in-sphere, respectively.

291. *Proposed by Editor.*

If through the vertices of any inscribed polygon tangents are drawn forming a circumscribed polygon, the continued product of the perpendiculars from any point in the circle on the sides of the inscribed polygon is equal to the continued product of the perpendiculars from the same point on the sides of the circumscribed polygon.

I. *Solution by Nelson L. Roray, Metuchen, N. J., and I. L. Winckler, Cleveland, O.*

The solution here given is made to depend upon the following proposition: Two tangents AB and AC are taken to a circle and the chord BC is taken. If from P any point upon the arc BC, PF $\perp$ BC, PD $\perp$ AB and PE $\perp$ AC, then $PF^2 = PD.\ PE$. This is easily proved by taking the similar triangles BDP and PFC and the similar triangles PBF and PEC. The same thing is true for any pair of tangents and the chord between the points of contact whether P is on the minor arc or the major arc, which is proved in a similar manner.

Denote the perpendiculars to the sides of the inscribed polygon by p_1, p_2, p_3, etc., and to the sides of the circum-polygon by r_1, r_2, r_3, etc.

$$
\begin{aligned}
\text{Then } p_1^2 &= r_1 \cdot r_2 \\
p_2^2 &= r_2 \cdot r_3 \\
p_3^2 &= r_3 \quad r_4 \\
&\cdots\cdots\cdots\cdots \\
p_n^2 &= r_n \cdot r_1
\end{aligned}
$$

$\therefore p_1^2 \cdot p_2^2 \cdot p_3^2 \ldots\ldots p_n^2 = r_1^2\, r_2^2 \cdot r_3^2 \ldots\ldots r_n^2$

or $p_1\, p_2 \cdot p_3 \ldots\ldots p_n = r_1 \cdot r_2 \cdot r_3 \ldots\ldots r_n$.

II. *Solution by Elmer Schuyler, Brooklyn, N. Y.*

Let ABC......L be the inscribed polygon and A′B′C′......L′ be the circumscribed polygon.

Let P be a point on the minor arc LA.

Let x_1, x_2, x_3 ...... x_n be the chords from P to A, B, C, ... L, respectively.

Let a_1, a_2, a_3 ...... a_n be the perpendiculars from P to the tangents at A, B, C, ... L, respectively.

Let h_1, h_2, h_3 ...... h_n be the perpendiculars from P to the sides AB, BC, CD ...... LA, respectively.

From similar right triangles.

$$a_1 : x_1 = x_1 : d, \text{ where } d = \text{diameter of circle.}$$

$$\therefore\ x_1^2 = a_1 d. \quad \text{Similarly,}$$

$$x_2^2 = a_2 d,$$

$$\cdots\cdots\cdots\cdots$$

$$x_n^2 = a_n d.$$

Now since the product of two sides of a triangle equals the product of the perpendicular upon the third side and the diameter of the circumcircle, we have

$$x_1 x_2 = h_1 d,$$

$$x_2 x_3 = h_2 d,$$

$$\cdots\cdots\cdots$$

$$x_n x_1 = h_n d.$$

Since $x_1^2 \cdot x_2^2 \ldots\ldots x_n^2 = x_1 x_2 \cdot x_2 x_3 \ldots\ldots x_n x_1$,

Therefore $a_1 d \cdot a_2 d \cdot \ldots\ldots a_n d = h_1 d \cdot h_2 d \cdot \ldots\ldots h_n d$.

$\therefore a_1 \cdot a_2 \cdot \ldots\ldots a_n = h_1 \cdot h_2 \ \ldots\ h_n$.

Credit for Solutions Received.

282. John Gaub, G. I. Hopkins, I. L. Winckler. (3)
283. H. E. Trefethen. (1)
285. I. L. Winckler. (1)
286. I. L. Winckler. (1)
287. Constance E. Adams, Norman Anning, G. O. Banting, T. M. Blakslee, John H. Bartz, J. E. Burnham, W. B. Carpenter, J. W. Ellison, John M. Gallagher, John Gaub, A. M. Harding, L. L. Harding, J. E. Helman, G. I. Hopkins, Joel Jenifer, Irvin E. Kline, Lida C. Martin, R. M. Mathews, H. G. McCann, Edward Morgan, H. A. Morrison, A. N. Meyer, Letitia O'Dell, C. A. Perrigo, T. E. Peters, Ray Quick, J. L. Riley, Nelson L. Roray, Irving Rowe, W. P. Russell, Jacob P. Sauter, Elmer Schuyler, H. H. Seidell, G. Sergent, C. H. Stoutenburgh, H. E. Trefethen, G. J. Van Buren, Florence Winslow, A. L. Womack. (39)
288. Norman Anning (2 solutions), T. M. Blakslee, E. G. Berger, G. O. Banting, J. E. Burnham, W. B. Carpenter, John M. Gallagher, A. M. Harding, L. L. Harding, J. E. Helman, E. A. Pollard Jones, Irvin E. Kline, R. M. Mathews, H. G. McCann, A. N. Meyer, Edward Morgan, H. A. Morrison, Letitia O'Dell, Nelson L. Roray (2 solutions), Elmer Schuyler, H. H. Seidell, G. Sergent, C. H. Stoutenburgh, I. L. Winckler, A. L. Womack. (27)
289. G. O. Banting, J. E. Burnham, R. M. Mathews, W. C. P. Meddins, Edward Morgan, H. A. Morrison, N lson L. Roray, Elmer Schuyler, H. H. Seidell, C. H. Stoutenburgh, G. Sergent, I. L. Winckler. (12)

290. John H. Bortz, G. H. Crandall, A. M. Harding, L. L. Harding, G. I. Hopkins, Joel Jenifer, Irvin E. Kline, R. M. Mathews, H. G. McCann, C. A. Perrigo, Edward Morgan, H. H. Seidell, Nelson L. Roray, Elmer Schuyler, G. Sergent, C. A. Smith, C. H. Stoutenburgh, I. L. Winckler. (18)

291. T. M. Blakslee, Norman Anning, A. M. Harding, Nelson L. Roray, Elmer Schuyler, I. L. Winckler. (6)

Total number of solutions, 108.

PROBLEMS FOR SOLUTION.

Algebra.

303. *Proposed by Nelson L. Roray, Metuchen, N. J.*

If $\dfrac{y+z}{pb+qc}=\dfrac{z+x}{pc+qa}=\dfrac{x+y}{pa+qb}$,

show that $$\frac{2(x+y+z)}{a+b+c}=\frac{(b+c)x+(c+a)y+(a+b)z}{bc+ca+ab}.$$

(Hall and Knight's Higher Algebra, p. 11, ex. 11.)

304. *Selected.*

Divide a number a into two parts such that the product of the mth power of one and the nth power of the other shall be a maximum. (Solve without the use of calculus.)

Geometry.

305. *Proposed by F. Eugene Seymour, Trenton, N. J.*

Given the three distances from a point within an equilateral triangle to the vertices to construct the triangle.

306. *Proposed by Editor.*

If a cube and an octahedron have a common circumscribing sphere, prove that their surfaces are in the same ratio as their volumes.

Trigonometry.

307. *Proposed by A. C. Smith, Denver, Colo.*

Show that $\cos 36^\circ \cos 72^\circ = \frac{1}{4}$.

In Problem 299, May issue, for $(41)^3$ *read* $(4!)^3$.

SCIENCE QUESTIONS.

By Franklin T. Jones,
University School, Cleveland, Ohio.

Readers of School Science *are invited to propose questions for solution—scientific or pedagogical—and to answer the questions proposed.*

Questions and Problems for Solution.

Answer Serially Numbered Questions.

Physics, University of California, August 14, 1911.

85. A cord is tied to two trees 8 feet apart. Suspended from the middle point of the cord is a camp-kettle weighing 20 lbs., the point of suspension being 3 feet lower than the ends of the cord. What is the tensile force in the cord?

2. A man carries a load hung from a stick resting on his shoulder. What are the relative positions of his hand, his shoulder, and the load when the force exerted by the stick upon the shoulder is: (a) twice the load; (b) one half the load?

3. A stone, specific density 2.5, weighs 50 lbs. How much work is available if the stone be lowered 10 feet, in water?

4. Describe an experimental method of showing that air is in vibration near a sounding bell.

5. A river bank slopes uniformly from air to water. Standing on the bank, the slope below the surface of the water appears to be less steep than that above the surface. Explain this fact, making use of a diagram.

6. Describe an arrangement of apparatus for the production by reflection of a "real image"; a "virtual image." Draw a diagram of the apparatus in each case.

7. Name several ways in which an electric current may be detected and measured.

8. Who discovered induced electric currents? Give a connected account of what you know of their cause, direction and duration.

9. What experimental proofs do you know that the poles of a magnet are of equal strength?

Entrance Physics, Massachusetts Institute of Technology.
TIME: TWO HOURS.

1. Make a careful distinction between uniform motion and uniformly accelerated motion. Explain the following terms: stability of equilibrium, momentum, potential energy.

81. A beam 30 feet long, weighing 200 pounds, is pivoted at a point 10 feet from the end A. At A a weight of 50 pounds is hung. What force is needed at a point 25 feet from A to keep the beam in a horizontal position?

82. A body whose specific gravity is 7.6 weighs 54.6 grams. What will it weigh in water? What will it weigh in oil whose specific gravity is 0.9? What is the volume of the substance?

4. What is a barometer, how constructed, and for what purposes used? How does it differ in principle from a thermometer?

5. Explain how to produce with a converging (positive) lens (1) a real magnified image; (2) a virtual image. Explain with diagram the use of the ordinary reading glass.

6. Explain exactly what you understand by boiling point, melting point, latent heat of fusion, and specific heat.

7. Why not use Leyden jars for ringing door bells? Explain the difference in behavior and characteristics of a bar magnet and an electrically charged body.

83. Forty voltaic cells in series are sending a current of one ampere through a coil of 22 ohms resistance. The resistance of one cell is 0.55 ohm. What is the E. M. F. of one cell?

Princeton University, Freshman Entrance Examinations, June 17, 1911.

CHEMISTRY.

Any dishonesty in the examinations, including the giving as well as the receiving of aid, will, if detected, permanently debar the candidate from entering the University.

(Three hours are allowed for this examination.)

1. Give the atomic-molecular theory and the facts which support it.

2. Show how the composition of water may be determined by weight and by volume.

3. Write molecular formulas for the following substances: ozone, sodium sulphate, carbon monoxide, aluminium chloride, potassium hydroxide, calcium carbonate, ferric oxide, phosphorus pentoxide, lead iodide, phosphoric acid.

Name the substances for which the formulas are: $Hg(NO_3)_2$, CuO, Ag_2SO_4, H_2O_2, Br_2, Au, H_2S, $Pb(OH)_2$, $BaCO_3$.

4. Give the sources, preparation, properties and uses of chlorine.

5. Tell what is meant by "neutralization," and give examples. Give the system of nomenclature of acids, bases and salts.

6. Give the sources, preparation, properties and uses of nitric acid.

7. Why does the air of a tightly-closed room, in which lamps are burning, become unfit to breathe?

What is the explanation of the explosions which often occur in houses where illuminating gas has been escaping?

What is baking soda, and how does it make the dough "light"?

Why does a lamp burn better with the chimney on than without it?

8. Describe either the manufacture of white lead, the making of caustic soda, or the refining of copper.

9. Explain and illustrate with several examples the meaning of each of the following terms: valence, allotropy, reduction, catalysis.

84. How many grams of sodium will be needed to combine exactly with a quantity of chlorine which at 18° C. and 740 mm. occupied a volume of 200 cc? What will be the weight of the resulting salt?

Atomic Weights: Na = 23; Cl = 35.5.

Solutions and Answers.

71. *From a Cornell Entrance Examination in Agriculture.*

A man has plowed a strip 6½ rods wide with furrows 30 rods long. How many acres has he plowed? How many turns has he made if the plow cuts 14 inches? How far has he traveled? How long did it take him if the team walked 2 miles per hour, and if an average of three minutes was lost at each turn? How much did it cost him at the rate of 40 cents an hour for man and team?

Solution by the Editor.

$$\text{Acres} = \frac{\text{length in rods} \times \text{width in rods}}{160} = \frac{6\frac{1}{2} \times 30}{160} = 1.21875 \text{ acres.}$$

$$\text{Turns} = \frac{\text{width of strip}}{\text{width of furrow}} - 1 = \frac{6\frac{1}{2} \times 5\frac{1}{2} \times 3 \times 12}{14} - 1 = 91 \text{ turns.}$$

$$\text{Distance traveled} = \text{furrows} \times \text{length of furrow} = 92 \times 30 = 2760 \text{ rods.}$$
$$= 8.625 \text{ miles.}$$

$$\text{Time to plow} = \frac{\text{distance}}{\text{rate}} + \text{time lost on turns} = \frac{8.625}{2} + \frac{92 \times 3}{60} =$$
$$4.3125 + 4.6 = 8.9.$$

$$\text{Cost} = \text{hours} \times .40 = 8.9125 \times 40 = \$3.57.$$

73. *Proposed by A. P. Andrews, Minneapolis, Minn.*

If it takes 90/300 of an erg of work to carry two units of charge from one charged body to another, what is the P. D. of the bodies?

Solution by C. A. Smith, Dexter, Iowa.

$$\text{P. D.} = \frac{\text{work}}{\text{charge}}; \quad \frac{90/300}{2} = 3/20 \text{ volt.} \quad \textit{Ans.}$$

74. *Proposed by A. P. Andrews, Minneapolis, Minn.*

The capacity of an electrical condenser is 15 units. What is its potential when it holds 225 units?

Solution by C. A. Smith, Dexter, Iowa.

$$C = \frac{Q}{V};\ 15 = \frac{225}{V} = 15 \text{ volts.} \quad \textit{Ans.}$$

75. *Proposed by A. P. Andrews, Minneapolis, Minn.*

A certain length of wire has a resistance of 10 ohms and a diameter of .08 mm. What is the resistance of another wire of the same material and length, but having a diameter of .32 mm?

Solution by C. A. Smith, Dexter, Iowa.

$$10 : x = .32^2 : .08^2$$
$$x = 0.625 \text{ ohm.} \quad \textit{Ans.}$$

76. *Proposed by A. P. Andrews, Minneapolis, Minn.*

Calculate the current strength in the circuit shown in Fig. 1. The E.M.F. of each cell is 1.5 volts, the resistance of each cell is 0.5 ohm, the resistance of each coil is 15 ohms, and the resistance of the connecting wires is negligible.

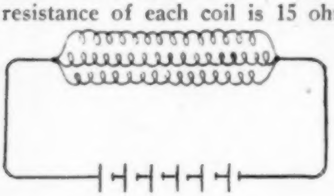


Fig. 1.

Solution by C. A. Smith, Dexter, Iowa

$$C = \frac{ne}{Re + nRi} \qquad \begin{aligned} Re &= 15 + 3 = 5 \text{ ohms.} \\ Ri &= 6 \times .5 = 3 \text{ ohms} \\ ne &= 6 \times 1.5 = 9 \text{ volts.} \end{aligned}$$

$$\therefore C = \frac{9}{5+3} = 1.125 \text{ ampere.} \quad \textit{Ans.}$$

ARTICLES IN CURRENT PERIODICALS.

American Forestry for April: "The War on Predatory Animals, Percival S. Ridsdale, with seven illustrations; "Relation of Insects to the Death of Chestnut Trees," A. D. Hopkins, with six illustrations; "The Underground Waters of New Mexico," Willard E. Holt, with two illustrations; "Windbreaks, their Influence and Value," George L. Clothier, with four illustrations; "The Harvard Forest," Theodore S. Woolsey, Jr., with four illustrations; "Dynamiting Stumps and Trees," with six illustrations; "Forestry at the Ohio State University," Prof. C. H. Goetz, with five illustrations; "Blight Commission Instruction," Prof. Hugh P. Baker, with one illustration; "Lumbermen and Forestry," W. C. Sykes.

Condor for March-April: "A Week Afield in Southern Arizona" (with seven photos), F. C. Willard; "*Passerella stephensi* in Marin County, California" (with three photos), Joseph Mailliard; "Nesting of the Canada Goose at Lake Tahoe" (with four photos), Milton S. Ray.

Educational Psychology for April: "Problems and Methods of Investigation in Handwriting," Frank N. Freeman; "Needed Research in Method," Clayton C. Kohl; "A Tentative Revision and Extension of the Binet-Simon Measuring Scale of Intelligence. Part II. Supplementary Tests (Continued). 2. The Completion Test. 3. Ball and Field Test of Practical Judgment. 4. Vocabulary Test," Lewis M. Terman and H. G. Childs; "Periods of Work in Learning," Daniel Starch; "Acquisition as Related to Retention," Naomi Norsworthy.

Journal of Geography for April: "Symposium: What is Most Needed in the Teaching of Elementary Geography?" Conducted by William M. Gregory. Opinions by J. W. Redway, R. E. Dodge, Charles F. King, Metha L. Wulf, Lewis M. Dougan, Nellie B. Allen, F. M. McMurray, Amos Farnham, Zonia Baber, Mark Jefferson, Isaac O. Winslow, D. C.

Ridgley, Anna Buckbee, Marion Weller, Cordelia O'Neil, William J. Sutherland, J. F. Chamberlain, George A. Mirick, and Charles E. Colby.

L'Enseignement Mathématique for March: "La théorie des équations intégrales," M. Plancherel; "Les rectrices. Etude de Géométrie physique," F. Butavand; "Les figures collinéaires. Un chapitre de Géométrie élémentaire," L. Crelier; Chronique. Commission internationale de L'enseignement mathématique.

The School World for April: "Schemes for Geography Teaching," A. H. Harries; "Scientific Apparatus Designed by Teachers;" "Continuation Schools;" "The Education of Young Boys," Shirley Goodwin.

Nature-Study Review for April: "Nature-Study as a Servant," Anna Botsford Comstock; "The Study of Birds with a Camera," Robert W. Hegner; "Agriculture in Minnesota Schools," Gilbert H. Trafton; "The Insect Life of Pond and Stream," Paul S. Welch; "Worcester Garden City Plan," R. J. Floody; "The Taming of Wild Animals," E. A. Lewis; "A Seventh Grade Soil Experiment," C. F. Phipps.

Photo-Era for April: "Sherril Schell, Portrait-Pictorialist," Sidney Allan; "The New Utocolor Paper," A. Le Mee; "Photography for the Advertiser;" "Spring-Pictures," William S. Davis; "Reflecting-Cameras for Other than Speed Work," C. H. Claudy; "Flower-Photography as a Hobby," Claude L. Powers; "Why We Sometimes Get Uneven Negatives," I. W. Blake.

Physical Review for March: "The Selective Transmission and the Dispersion of the Liquid Chlorides," H. H. Marvin; "The Distribution of Current in Point-plane Discharge," Robt. F. Earhart; "The Effective Depth of Penetration of Selenium by Light," F. C. Brown; "Rays of Positive Electricity from the Wehnelt Cathode," Chas. T. Knipp; "Note on the Measurement of the Peltier E. M. F.," Harold C. Baker.

Popular Science for April: "On the Need of Administrative Changes in the American University," George T. Ladd; "Science in the Service of Highway Construction," Clifford Richardson; "The Brooklyn Botanic Garden," C. Stuart Gager; "Alexander von Humboldt," Edward F. Williams; "A Review of Three Famous Attacks upon the Study of Mathematics as a Training of the Mind," Florian Cajori; "The Red Sunflower," T. D. A. Cockerell; "The Medical Side of Immigration," Alfred G. Reed; "Ancient Portals of the Earth," James Perrin Smith; "Ptomaines and Ptomaine Poisining," Edwin LeFevre; "Science and International Good Will," J. McKeen Cattell.

Psychological Clinic for April: "The School Feeding Movement," Louise Stevens Bryant; "Administration of School Luncheons," Alice C. Boughton; "The Training of the School Dietitian," Mary Schwartz Rose; "Effects of Coffee-Drinking upon Children," Charles Keen Taylor.

Unterrichtsblätter für Mathematik und Naturwissenschaften, Nr. 2: "Die biologischen Reaktionen und ihre Bedeutung für die Naturwissenschaften," Professor Dr. H. Miessner; "Ueber die Behandlung des Planktons im Schulunterricht und die Stoffauswahl der Biologie in den oberen Klassen der Oberréalschulen," E. Krüger; "Allgemeines Verfahren zur Ermittelung von Parallelperspektiven," Dipl.-Ing. Carl Herbst; "Ein Modell zur Veranschaulichung des Peripheriewinkelsatzes und die Uebertragung dieses Satzes auf die gleichseitige Hyperbel," W. Rottsieper.

Zeitschrift für den Physikalischen und Chemischen Unterricht for March: "Versuche über elektrische Schwebungen," P. Spies; "Messung thermoelektrischer Kräfte in den Schlülerübungen," W. Masche; "Einige elektrische Apparate zur Selbstherstellung," B. Thieme; "Demonstration von Wechselstrombegriffen mit einfachen Mitteln," A. Meir; "Eine Vorrichtnng zur Messung der Zentrifugalkraft," P. Maey; "Die zeichnerische Darstellung der Fernrohre," R. Winderlich.

Zeitschrift für Mathematischen und Naturwissenschaftlichen Unterricht for March: "Die Summe aller Produkte von je *k* verschiedenen Faktoren zu bestimmen, die sich aus den *n* ersten natürlichen Zahlen bilden lassen," Dr. Ernst Eckhardt; "Ein Zahlenkunststück," E. Stucke; "Eine Eigenschaft der Quersumme," E. Stucke; "Konstruktion des Quadrates des Kreises," Dr. C. H. L. Schmidt; "Zur Geometrographie," edited by K. Hagge.

ELEMENTARY PHYSICS.

Pittsburgh High School, Academic Dept., B Class, June, 1911.

Time limit, 3½ hours.

In all problems care should be taken to give proper dimensions, as "*g*," "*g/cm²*," and the like to the quantities used. If the student's solution of a problem does not show that he understands the principle involved, no credit will be given for the problem, even though a correct result may have been obtained.

1. If a hole extended straight through the earth, including its centroid, and a body were let drop down this hole, where would its velocity be greatest, zero, constant, positively accelerated, negatively accelerated? There is presumed to be no air resistance. Answer in the form of a diagram.

2. A locomotive on one track pulls by means of a rope a car on a parallel track, the tension of the rope is 1,000 lbs., the rope makes an angle of 25° with the rails. Find by construction the value of the component of the 1,000-lb. pull that produces sidewise pressure upon the rail, and of the component that tends to move the car along the track.

3a. To increase the velocity of a 100-ton train by 4 ft. /sec. /sec. requires the locomotive to pull upon the train with a force of 25,000 lbs. (the pull of a locomotive upon its train is called the draw-bar pull). What must be the draw-bar pull of a locomotive that is to produce an acceleration of 2 ft. /sec. /sec. upon a 300-ton train? There is presumed to be no friction or air resistance.

b. What will be the velocity of the first train in miles /hr. ½min. after it has left the station, the draw-bar pull to remain unchanged?

4. The area of the pump piston of a hydrostatic press is 10 cm², the total pressure exerted upon it is 50 kg., the area of the large piston of the press is 1,500 cm², find the total pressure upon this piston. Disregard friction.

5a. The radius of the wheel of a copying press is 7 in.; two forces of 25 ibs. each, acting clockwise are applied to the rim of the wheel; the distance from the middle of one thread on the screw to the middle of the next is ⅛in. Calculate the magnitude of the pressure that would be produced upon the book beneath the screw, if there were no friction; the actual pressure efficiency being 75%. Use the roughly approximate value of pi in the calculation.

b. Through how great a distance must each force act in order that the end of the screw may move downward 1 in.?

6a. Sketch two waves that would produce sensations alike in pitch but different in loudness and quality.

b. What difference would you expect to find between the length and the thickness of the bass strings (giving sounds low in pitch) and the treble strings (giving sounds high in pitch) of a piano?

7a. The wave sent out by a tuning-fork making 100 vib. /sec., in air in which compressional waves travel 345 m./sec., divide between two tubes which afterward join. One of these tubes is 69 cm. long. Give two lengths of the other tube either of which will cause the two parts of the wave to interfere destructively at the juncture of the tubes.

b. For what two reasons does a mixture of ice and salt absorb heat?

8. Five liters of water at 4°C in a 4.4-lb. iron kettle receives 60,0001.c/min. from a gas flame. What is the temperature of the kettle and

water at the end of 10 minutes? Spec. heat of iron is .11. How much of the water, if any, is changed into steam during the 10 minutes?

9. The heat required to raise 1 lb. of water 1 F. degree is called a British thermal unit, B.T.U. 1 B.T.U. is equivalent to 778 ft. lb. 1,000 B.T.U. are supplied each second to an engine of 10% efficiency. How much mechanical work is done by the engine per second? What is the horse power of the engine?

10a. Sketch a mirror with a source of light in such a position that the reflected light is a beam.

b. What kind of an image is formed by the objective lens of a projecting lantern?

11. Locate by wave-front construction the principal focus of a plano-convex lens of crown glass, R, 5 cm., R', infinity, chord, 5 cm., index of refraction, 1.5.

12a. By what methods, exclusive of dispersion, may colored light be obtained from white light?

b. What is the most economical method of producing light of a certain color, yellow, for example?

13a. A body having 10,000,006+ units of electricity and 9,999,994— units is electrically connected with a second body having 9,999,994— units and 10,000,006— units. Show by a series of drawings, the original electrical condition of the bodies, what occurs while they are connected, and, their final condition.

b. Two charged bodies ½ cm. apart, repel each other with a force of 40 dynes, one of them has a charge of 5+ units, what is the charge on the other body?

14. Diagram the action of a copper oxid (CuO) — sulphuric acid — zinc cell. State what are formed and what are used during the action.

Or make diagram illustrating the action during the discharge of a secondary cell.

15. A voltmeter connected in parallel with a certain tungsten lamp reads 110, an ammeter connected in series with the lamp reads .50, the source of e.m.f. is direct current generator.

a. Diagram the connections. b. Calculate the resistance of the lamp. c. The resistance of 4 such lamps connected in the usual manner. d. The cost of running the four lamps 1,000 hours, 1 kw. hr. costs 10 cents. e. The candle power of each lamp.

16. Sketch the magnetic field of a coil of one turn, current flowing upward in the right hand wire, put 4 compass needles in the field and mark the poles of the coil.

17a. Diagram the circuit used to supply energy for house lighting.

b. 5 amperes at 110 volts is required for a certain house. The secondary of the transformer has 55 turns, the primary 1,100 turns, what voltage is impressed upon the primary? c. If there were no other house to be supplied, how strong a current would flow through the line from the power house? Assume the efficiency of the transformer to be 100%. d. Draw a section of a transformer, label the parts. Do not show connections.

P. M. Dysart, *Head of Physics Department.*

OPAQUE PROJECTION OF LARGE OBJECTS.

A new realm of usefulness has been opened up for optical projection by the unique balopticon recently devised and constructed by the Bausch & Lomb Optical Company. Designed for the projection of opaque objects and illustrative material direct on a much larger scale than ever before attempted, it has proved entirely practical in operation and presents new possibilities for this attractive form of projection. The accompanying cut gives one a good knowledge of the apparatus.

This new lantern can be used to advantage in projecting full-page illustrations from large magazines, or photographs and engravings of any size up to twenty inches square. In educational work, too, lie some of its greatest possibilities for service as it is especially suitable for projecting large embryos and anatomical specimens. All subjects are clearly shown in their natural form and coloring in greatly enlarged images, conveying a certain sense of the true relation of the parts projected.

For the attainment of such a wide scope of service this balopticon was constructed with an opening for objects measuring *twenty inches square*. To cover this wide area with sufficient illumination to the very edges was the first problem to be solved. This was successfully accomplished by mounting two large 90° arc lamps in their light-tight houses at a suitable angle to the object table to cover the exposed area with the cone of light. These illuminants were placed near enough the object to effect their purpose without the use of condensers, thus obviating the slight absorption of light which might be attributed to that source. Their position on opposite sides of the dark chamber also results in eliminating all possible shadows.

The two adjustable rheostats regulating the electric current are securely mounted, one on either end of the base, while each lamp is controlled by a snap switch conveniently placed. Excellent results are obtainable with 50 amperes of current, 25 amperes to each lamp, although more may be used if desired.

A PURELY GEOMETRICAL PROOF OF THE PYTHAGOREAN THEOREM ILLUSTRATING THE PRINCIPLE OF CONTINUITY.

By Clarence Ohlendorf,
Park Ridge, Ill.

Case I. Angle A acute.

Theorem. $a^2=b^2+c^2-2cd$.

From Fig. 1 we observe:

$$(1)\begin{cases}\triangle BCG=\triangle HBE.\\ \triangle CAD=\triangle BCD=\triangle FCE.\\ a^2=2\triangle HBE+2\triangle FCE.\\ b^2=2\triangle KCE+2\triangle JAE.\\ d^2=2\triangle JAE.\\ 2\triangle BCG-2\triangle JAE=c^2-2cd.\\ \triangle KCE=\triangle CAD'=\triangle CAD.\end{cases}$$

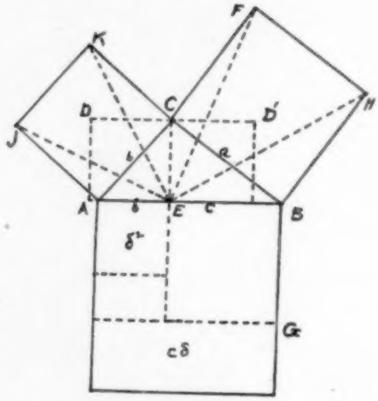


Fig. 1

Using (1) we may write,

(2) $2\triangle HBE+2\triangle FCE=2\triangle KCE+2\triangle JAE-2\triangle JAE+2\triangle BCG$,

which may be written,

(3) $a^2=b^2+c^2-2cd$. Q. E. D.

Case II. Angle A a right angle.

Theorem. $a^2=b^2+c^2$.

This comes from Case I by putting $d=0$. Plotting the values of d as a function of angle A the following curve was obtained. Its equation is

(4) $d=b\cos A$. A varying from 0 to..180° in counter-clockwise direction.

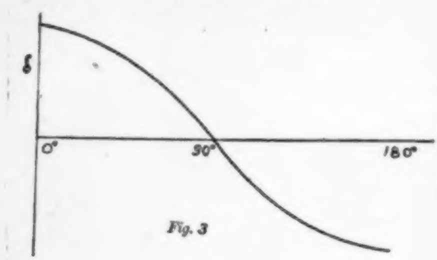


Fig. 3

The table shows how d varies with angle A. d is a continuous function of A.

	d	A varies
Acute ∠	—	0°....90°
Right ∠	0	90°
Obtuse ∠	+	90°...180°

Case III. Angle A obtuse.

Theorem. $a^2=b^2+c^2+2cd$.

The first five equations of (1) hold for Case III. In place of the last two equations we have from Fig. 2.

$$(5).\ \begin{cases}2\triangle BCG-2\triangle JAE=c^2+2cd.\\ \triangle KCE=\triangle CAD.\end{cases}$$

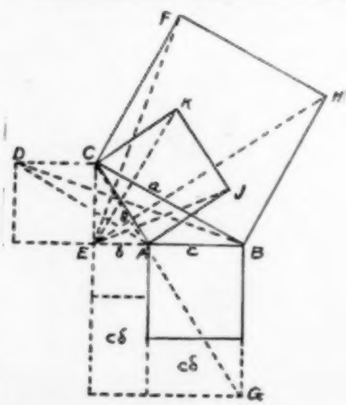


Fig. 2

Using (1) and (5) we may write,

(6) $2\triangle HBE+2\triangle FCE=2\triangle KCE+2\triangle JAE+2\triangle BCG-2\triangle JAE$,

which may be written,

(7) $a^2=b^2+c^2+2cd$. Q. E. D.

The similarity in the proof of Case I and Case III is to be noted.

HOW MOVING PICTURES ARE USED.

In the April *Woman's Home Companion* there is an extraordinarily interesting account of the development of moving pictures as definite educational agencies. The article includes a number of specific reports of the uses to which moving pictures are being devoted. Following are some of them:

"A Louisiana teacher changed the entire character of picture-shows in her town by asking the manager to coöperate with her in class work. When her pupils in literature were reading 'The Vicar of Wakefield' the manager exhibited a picture film of that classic. When the geography class began to study about Switzerland, the manager secured films showing Alpine climbing. That manager is doing a bigger business, the school children are receiving clearer ideas of their class work, and the parents are following what their children are doing in school.

"The Iowa Federation of Women's Clubs has started a movement to induce moving picture managers to show Red Cross films and other hygienic subjects throughout the state. The senior class of the high school at Florence, Colorado, has made the introduction of high-grade films into the local picture houses their year's work in civics.

"The Woman's Municipal League of Tecumseh, Nebraska, made an arrangement with the manager of the Lyric Theater of that city to give them a percentage of one day's receipts each week, and exhibit certain films illustarting the civic needs and work of the city. This has brought manager, patrons, and social workers closely together for the city's good.

"The president of the Great Northern road is encouraging immigration to the Northwest by sending out twenty thousand feet of special films showing industrial and agricultural life along its route. These are displayed in cities where congestion should suggest the slogan, 'Back to the Farm.'

"The Tarrant County Medical Society, Ft. Worth, Texas, has started an educational campaign by showing in moving pictures how to keep food clean and pure, the care of milk, sanitary dairies, etc.

"The New York State Board of Charities wished to interest the public in the work and methods pursued in various state institutions. It had a film company take moving pictures, in orphanages, reformatories, hospitals, schools for the blind and the crippled, 'homes,' etc. These are now exhibited in commercial clubs and at conventions and county fairs."

SIMPLE METHODS OF DETERMINING THE HORIZONTAL COMPONENT OF THE EARTH'S MAGNET FIELD.

BY RAYMOND B. ABBOTT,
University of California, Berkeley.

A simple direct-reading method for measuring H, the horizontal component of the earth's magnetic field, has been found to be very satisfactory by the writer.

A portable ammeter, which can be read to thousandths of an ampere accurately, an adjustable resistance, a battery cell, and a tangent galvanometer are all connected in series. The galvanometer being adjusted in the position where the value of H is to be found, adjust the resistance until the galvanometer reads the angle whose tangent is equal to one-

tenth the galvanometer constant $\frac{2\pi n}{r}$, where n is the number of turns and r the mean radius of the coils.

If $I = \frac{10\ H}{\frac{2\pi n}{r}} \tan\theta$, then our equation becomes,

$$I = \frac{10\ H}{\frac{2\pi n}{r}} \times \frac{1}{10} \times \frac{2\pi n}{r}, \text{ or } I = H, \text{ numerically.}$$

The ammeter now reads H as well as I.

The best kind of galvanometer to use for this purpose is one so made that

$$\tan^{-1} 2\pi n/10\ r = 45°,$$

where the sensitiveness of the galvanometer is the greatest. A good arrangement is to let $n = 20$, then $r = 12.566$ cm. Then

$$2\pi n/10\ r = \frac{2 \times \pi \times 20}{10 \times 12.566} = 1, \text{ and}$$

$$I = H \tan\theta.$$

For, $\theta = 45°$,

$$I = H, \text{ numerically.}$$

HEALTH RESORTS AND INFECTION.

Among the public the idea is occasionally found that cities or communities frequented by tuberculous persons present conditions favorable for the infection of the well. While it was difficult to secure conclusive evidence to prove the error of the assumption referred to, yet a study of the question would indicate that casual contact and house infection were of relatively slight importance, and that if the presence of a large number of "open cases" were a factor of great importance in spreading tuberculosis, there should be some correlation between the death-rate of imported and acquired cases in the various communities. None of the states except Arizona classifies separately the deaths from imported cases and those from locally acquired tuberculosis. It is found that in Denver, which also makes this distinction in classifying these deaths, the death-rate from locally acquired tuberculosis, while it fluctuates somewhat, is low and is certainly not increasing. California also classifies these deaths according to length of residence and while the line cannot be distinctly drawn between imported and locally acquired cases, yet the conclusion is that the death-rate from tuberculosis is no higher in southern California, which receives most of the imported cases, than it is in the central and northern portions of the state. The abundance of sunshine, which quickly destroys the germ, and the possibility of outdoor life in most of these communities, together with the supervision exercised by physicians over this class of patients and the instruction given them as to the spread of infection and adoption of correct hygienic measures, make these communities as safe for the general public as the communities less favored by climate. *The Journal of the American Medical Association* says that tuberculosis is notoriously a disease dependent on poverty, malnutrition, dust, bad air, and bad housing, these conditions in the closely populated industrial centers with less supervision over the cases really afford much greater opportunity for the spread of this infection than the presence of many open, but supervised cases, as in the health resort communities.

THE ASSOCIATION OF OHIO TEACHERS OF MATHEMATICS AND SCIENCE.

The Association of Ohio Teachers of Mathematics and Science held its ninth annual meeting in Chemical Hall, Ohio State University, Columbus, O., March 29 and 30, 1912.

A new feature of the program was the session Friday at 8 P. M. At this time Professor Lynds Jones of Oberlin College gave a most instructive and interesting lecture on "The Native Birds of Ohio and Their Economic Value." Professor Jones spoke at length of the great benefit rendered by many of our common birds in the fields and orchards of the open country as well as in and about towns. Very few even of the supposedly destructive birds, such as hawks and owls, take any appreciable per cent of their living from the poultry yard, but feed on mice, snakes, and other pests of barn and field. In the case of other birds damage done to fruit or crops is largely offset by the destruction of great numbers of weed seeds and injurious insects on which these birds so generally live. The lecture was illustrated with a goodly number of slides.

Following the lecture a letter was read from Professor T. E. McKinney, now of the University of South Dakota. Professor McKinney was actively interested in organizing the Ohio association, and was its first secretary. This letter gave a brief sketch of the first meetings in 1904, and emphasized the purpose for which the association was founded and still continues, viz: "That college and high school men may work side by side for the improvement of the teaching of mathematics and science throughout the state."

A short social hour followed, with opportunity for enrollment of members.

At the general session Saturday morning several items of business were transacted, including the reading and approving of the minutes of the last annual meeting and the treasurer's report; the appointments of auditing and nominating committees; and a motion to drop names from membership roll if dues were in arrears more than one year, previous notice having been sent to such members.

Following the business meeting Professor J. Warren Smith, director of the Columbus Weather Bureau, gave a talk on "Atmospheric Phenomena and Their Interpretation." The talk was illustrated with numerous slides showing among other pictures the first station on Mt. Washington, the later one on Pike's Peak, some of the various instruments used by the weather bureau, a goodly number of charts and maps, and some interesting pictures of the results of storms of different kinds. Professor Smith said the per cent of correctness of forecasts had not been increased so much in later work, but the interval of time covered was much greater.

Hon. Frank W. Miller, Commissioner of Schools, was not present to give his address on "The Coming of Agriculture into Ohio Schools," but Mr. R. O. Austin, Commercial High School, Columbus, made some very interesting remarks on experiments, in the class room and in his own home, regarding the effect of the humidity of the atmosphere on the necessary degree of temperature. The meeting then adjourned to sectional meetings.

The science section was presided over by Vice-President Ralph W. Buck and the following papers were presented:

1. "The Nature and Economic Value of Ohio Soils," Mr. Geo. N. Coffey, director of Ohio Soil Survey, State Experiment Station, Wooster.

2. "The Unknown in Physics," Professor J. F. Culler, Miami University, Oxford.

Discussion followed, with some experiments and demonstrations. In the mathematics section, Professor Anderegg of Oberlin presiding, R. E. Offenhauer, principal of the Sandusky high school, gave the first paper on "Motivation in High School Mathematics." While admitting the value of the teaching of mathematical truths for their own sake and for the cultivation of an appreciation of the importance of mathematical knowledge in modern life, he contended that "the vitality and interest added to a course in mathematics by concrete problems and the opportunity of handling and measuring things can scarcely be estimated." This was followed by the report of the committee on a High School Curriculum in Mathematics, of which Professor K. D. Swartzel of Ohio State Uuiversity was chairman. In the absence of the other members of the committee, the entire report was undertaken by Professor Swartzel. Three different sets of questions had been sent out. The first set went to about 500 high school principals, with some thirty-seven returns. The second set, sent to seventy different teachers of college mathematics, received some twenty-five returns, and the third set, 1,500 in number, went to members of college mathematics classes and there were 300 returns. Professor Swartzel took up the responses to the first set quite fully. The consensus of opinion seemed to be that the present curriculum was favorable for those graduating from high school and entering college, but not for those who do not enter college or who enter technical schools. In many cases two full years of algebra for high school were recommended.

In the responses from college classes it was admitted that the readjustment of the curriculum would meet some of the difficulties, but in both reports the conclusion seemed to be that the *great* problem was not that of the curriculum, but that of the teacher. "Poorly prepared teachers arouse no interest." "Teachers do not insist on accuracy and honesty." "Theory is neglected; work is too mechanical." "There is lack of independent thought," etc. Owing to lack of time the report from the teachers of college mathematics was not given, neither was there opportunity for any discussion of the reports.

At the general session of the afternoon, reports of the committees were heard, and Professor Geo. R. Twiss, state inspector, Ohio State University, was appointed delegate from the association to the American Federation. On motion of Professor Yanney of Wooster it was voted that the officers of the closing year draw up resolutions appropriate to the work and influence of Professor J. L. Gilpatrick of Denison University, news of whose death had just been received. Professor Gilpatrick was one of the charter members of the association.

The association then listened to a paper by Thos. E. French, professor of drawing in Ohio State University, on the subject "Graphics in Mathematics and Science." He contended that drawing is a language, and a very necessary one in the pursuit of nearly all lines of activity, both mathematical and otherwise, and he spoke of the frequent inability of men doing work along mechanical lines to picture the simplest pieces of machinery with anything like correctness. Professor Geo. R. Twiss then exhibited the Bausch and Lamb balopticon, or reflectoscope, showing the excellent results possible with post cards, magazine cuts, and even the printed paragraph. The sectional meetings followed. In the physics and chemistry section these papers were given:

1. "Industrial Physics in the High School," J. W. Simons, Woodward High School, Cincinnati.

2. "The Metallurgy and Commercial Analysis of Iron Ores," Professor J. D. Demorest, Ohio State University.

3. "Elimination of Waste in High School Chemistry," Albert J. Schantz, Steele High School, Dayton.

The earth science and biology section held its own separate meeting for the second time in the history of the association. Three excellent papers were submitted:

1. "Laboratory Work in High School Physical Geography," Professor Geo. D. Hubbard, Oberlin College.

2. "Desirable Work in Agriculture for Ohio Schools," Superintendent Lester L. Ivans, Lebanon.

3. "High School Study of Thallophytes," Professor Frederick D. Grover, Oberlin College.

In the mathematical section Professor B. F. Yanney of Wooster gave a talk on "Some Suggestions on the Teaching of Trigonometry," with many practical ideas for the progressive teacher, such as graphical treatment of functions and solution of trigonometric equations and the reduction to a common basis of the error of angles and sides in the solution of triangles. He urged the individual problem. Then followed a talk by Dr. E. A. Lyman, professor of mathematics, Michigan State Normal School, Ypsilanti, Mich. He gave numerous historical illustrations of the methods of teaching mathematics among early nations, and spoke of some of the recent movements in France, Germany, England, and the United States. Disappointment was felt in both the morning and afternoon sessions that the time for discussion was so limited.

The attendance at all the meetings was a very great gain over that of recent years, and the feeling was universal that the change of time from December to April had been a wise one.

The following officers were elected for the ensuing year: President, Ralph W. Buck, Stivers Manual Training High School, Dayton, Ohio; Vice-President, S. E. Rasor, Ohio State University, Columbus, Ohio; Secretary-Treasurer, Miss Harriet E. Glazier, The Western College for Women, Oxford, Ohio; Assistant Secretary, Miss Helen E. Rinehart, Central High School, Toledo, Ohio.

Harriet E. Glazier, *Secretary.*

EASTERN ASSOCIATION OF PHYSICS TEACHERS.

The sixty-first meeting of this association was held Saturday, March 2, at the Massachusetts Institute of Technology. Meeting was called to order by President Griswold at 9:45, when the secretary presented his interesting annual report which showed the association to be in an excellent and flourishing condition. This was followed by an itemized report from the treasurer, which showed a substantial balance on hand.

The committee on new apparatus, Mr. Homer LeSourd, as chairman, presented a very interesting and helpful report on some new apparatus which had recently been put on the market. Mr. Kamm, an ingenious device for showing the gridiron compenting pendulum. A similar device being described in the current number of the ZEITSCHRIFT FUR DEN PHYSIKATISCHEN UND CHEMISCHEN UNTERRICHT.

The committee on magazine literature also had an interesting report to make. Their report consisted of leading physics articles and several of the more useful journals which print, from time to time, articles bearing upon physics.

By no means the least important was the report of the committee on current events. This committee has for its purpose the presentation to the meetings of the association, the new things that are going on in the physics world.

Several new members were elected to membership.

Dr. C. Hayes then addressed the meeting on the subject of Pyrometry. He made this a most interesting and helpful address, describing the new style and type of pyrometers. He mentioned three types of these, namely: Resistance, thermo-electric and radiation pyrometers. His reference and explanation of the method of optical pyrometry was extremely helpful.

Professor William J. Drisko then briefly outlined the work as given to all of their students in the institute during the first two years of their course. He also spoke with reference to the kind of preparation pupils fitting themselves for admission should have. The afternoon session was spent in a very profitable visit and investigation to the Christian Science Publishing Company's plant. The method of heating and ventilating their great auditorium was fully explained and demonstrated. On the whole, the meeting was one of the very best the association has ever held.

C. H. S.

BOOKS RECEIVED.

The Teaching of Physics. By C. Riborg Mann, University of Chicago. Pages xxv+304. 13x20 cm. Cloth, 1912. $1.25 net. The Macmillan Company, New York.

Bookkeeping, Introductory Course. By George W. Miner. Pages 126+xxii. 16x24cm. Cloth, 1912. 90 cents. Ginn & Co., Boston.

Linear Polars of the *K*-Hedron in *n* Space. By Harris F. MacNeish. 25 pages. Paper. 27 cents postpaid. The University of Chicago Press.

Agricultural Education in the Public Schools. By Benjamin M. Davis, Miami University. Pages vii+163. 15x23 cm. Cloth, 1912. $1.12 postpaid. The University of Chicago Press.

Teachers' Guide and Classification "600 set." Keystone stereographs and lantern slides. 347. 14x20 cm. Cloth, 1911. Keystone View Company, Meadville, Pa.

The Euclidean or Common Sense Theory of Space. By John N. Lyle.

Report on Vocational Training in Chicago and in Other Cities. By a Committee of the City Club of Chicago. Pages xiii+315. 17x25 cm. Cloth, 1912. $1.50. City Club of Chicago, Publishers.

Kimball's Commercial Arithmetic. By Gustavus S. Kimball. Pages vii+418. 15x20 cm. Cloth, 1911. G. P. Putnam's Sons, New York City.

High School Education. By C. H. Johnston. Pages xxii+555. 1912. Charles Scribner's Sons, New York.

BOOK REVIEWS.

The Teaching of Primary Arithmetic, by Henry Suzzallo, Professor of the Philosophy of Education, Teachers College, Columbia University. Pp. xi+124. 12x18 cm. 1912. Price, 60 cents. Houghton, Mifflin Company, Boston.

It is to be hoped that the title of this book will not prevent teachers of secondary mathematics from securing a copy and reading it carefully. There is much of value in it for every teacher of mathematics, since considerable of the author's discussion may be safely carried over into high school mathematics. But to the teacher of primary arithmetic this

book should prove a source of inspiration to a better understanding of the problems of teaching and to more efficient teaching.

The scope of the book is indicated by the topics of the chapters: The Scope of the Study; The Influence of Aims of Teaching; The Effect of the Changing Status of Teaching Method; Method as Affected by the Distribution and Arrangement of Arithmetical Work; The Distribution of Objective Work; The Materials of Objective Teaching; Some Recent Influences on Objective Teaching; The Use of Methods of Rationalization; Special Methods for Obtaining Accuracy, Independence and Speed; The Use of Special Algorisms, Oral Forms and Written Arrangements; Examples and Problems; Characteristic Modes of Progress in Teaching Method. H. E. C.

Bookkeeping, Introductory Course, by George W. Milner. Pages 126+xxii. 16x24 cm. Cloth, 1912. 90 cents. Ginn & Co., Boston.

This is a new work based upon and growing out of the former text, "Accounting and Business Practice," by John H. Moore and George W. Miner.

The plan of the book is simple, yet comprehensive. Three aims have guided the author in grading and developing his material: (1) To interest the pupil; (2) To educate the pupil through the use of this material; and, (3) To give the pupil practical knowledge and skill. Power to work independently rather than mere facility in mechanical imitation is the aim throughout.

To supplement his own successful experience the author has been fortunate in securing the advice and detailed assistance of a number of the foremost teachers and authorities in the field of bookkeeping. This work is presented to the public with confidence that it represents the best theory and practice of this country at this time.

It contains an appendix on single entry with this the pupil will have the opportunity of comparing clearly and comprehensively this with double entry. Several pages are devoted to defining common terms used in bookkeeping. The loose-leaf method and filing devices are also given proper attention. Commercial terms used in business receive proper treatment in being defined in understandable terms. A complex index is also given. Mechanically the book is put together in the best manner possible, the paper is of excellent quality, type well chosen, in fact the book has been made to use. C. H. S.

High School Geography, Physical, Economic, and Regional, by Charles R. Dryer. Pts. I and II. 340 pp., with illustrations and maps. American Book Company, 1911. $1.20.

The nearest approach to the method of treatment of secondary school geography advocated by the leaders in this field, is the book before us. It is likewise the farthest departure from the ideals of the Committee of Ten that has appeared since that committee made its report. While the author has made a close approach here to the recommendations of the recent committees of both the N. E. A. and the Association of American Geographers, he has shown much courage in standing out absolutely alone in his method of handling his materials. If the schools realize how closely he has come to what they have been calling for, the book will be a good seller; if they do not such a radical work will fail.

In the book, systematic physical geography has been reduced to a minimum; *physical* geography for its own sake is nearly absent. Description is good. Geographic relations, cultural adjustments and responses to physical conditions are carefully worked out and constitute the theme

and spirit of the book. Most maps are on an equal area projection—a decided advantage. Even though Part I is called Physical Geography it is freely interspersed with interpretations of relations. It covers about 250 pages. Economic geography covers about seventy-five pages and constitutes Part II. Part III, Regional Geography, is soon to come out.

G. D. H.

Physiography for High Schools, by Albert L. Arey, Frank L. Bryant, William W. Clendinin, and William T. Morrey, of the New York City High Schools. Pages vi+450. 14x21 cm. Cloth, 1912. D. C. Heath & Co., Boston.

This splendid book has been gotten out by these authors who have long been teaching the subject of physiography, and who have felt the need of a text which would present the subject-matter from the high school point of view. It has been written largely for the purpose of meeting the needs of that ever increasing number of pupils who complete their education in the secondary schools. This text is written in a clear, concise, and understandable way, so that a secondary pupil cannot help but become interested in it. The matter presented has been in successful use in the class rooms of the authors for several years. It contains more than enough matter for one year's work. It is divided into four parts. Part one discusses the earth as a planet; part two is devoted to the air; part three considers the sea, and part four discusses light. Altogether, there are twenty-seven chapters. There are two hundred thirty-four splendid illustrations, many of them being halftones from actual photographs. There are a number of diagrammatical drawings, also several maps and charts, all of which help to illustrate the subject-matter. At the end of every chapter is a *splendid* list of questions bearing upon the subject treated in that chapter. The principle paragraphs begin with bold-face type and when technical terms are used for the first time they are italicized. The authors lay special stress on the fact that sentences printed in italics should be memorized. In the appendix there is a splendid bibliography of books of a kindred nature. There is a complete index of twelve pages.

Mechanically, the book represents perfection. The type is large and clear. Boards of education and teachers looking for texts on physiography to introduce into their schools cannot do better than to decide upon this one. It deserves wide circulation. C. H. S.

The Elements of Qualitative Chemical Analysis, by Julius Stieglitz, University of Chicago. Volume I, theoretical part, pp. 312, $1.40 net. Volume II, laboratory manual, pp. 151, $1.20 net. The Century Company, New York. 1911.

The chief object of the author in writing this book was to satisfy the often expressed wish to have his lectures on qualitative analysis available for reference and for a wider circle of instruction.

It consists of four parts, two in each of the volumes. Parts I and II embody the author's lectures in the form to which they have developed in the course of the last sixteen years, since the appearance of Ostwald's "Wissenschaftliche Grundlagen der Analytischen Chemie."

The professional method of work, whether routine or research work of the academic or the industrial laboratory is involved, inevitably consists in first making an exhaustive study of the *general chemical* aspects of the subject under examination; it includes a thorough study of books of reference and of the original literature on the subject; and when the experimental work is finally undertaken, it is carried out with a critical, searching mind, which questions every observation made and every process used.

The method of the author aims at developing these habits of the professional, productive chemist.

In Part I a somewhat thorough and critical study is first made of the fundamental general chemical principles which are most widely involved in analytical work; while the applications of these principles to elementary qualitative analysis are discussed in Part II, in closest connection with the laboratory work covering the study of analytical reactions in Part III and a course in systematic analysis as Part IV.

The material is presented not as a finished subject but as a growing one, numerous references to standard works and to the current literature are given and those suitable for reading by the young student are specially indicated.

By putting the subject-matter of part III largely in the form of questions, which demand of the student careful observations and thoughtful interpretation of the same, the author seeks to arouse and develop the critical, questioning attitude of the professional chemist.

Chemical and physical constants are given and used wherever it is possible, although these "constants" have in part, only a temporary standing, as more exact work will continually modify their numerical values and probably limit the field of their rigorous application.

"The latter facts can be impressed on the student and still the invaluable principle be inculcated in his mind, that chemistry is striving to express its relations, as far as possible, in mathematical terms, exactly as its sister science, physics, has long been doing."

This work by reason of its arrangement of material, clearness of expression, and the adoption of recent methods of approved worth deserves to be regarded as a *valuable* addition to the treatises on this subject and not merely as "one more." A. L. S.

Handbook of Nature-Study, by Anna Botsford Comstock. 938 pages, illustrated by over 1,000 figures. Published by The Comstock Publishing Company, Ithaca, N. Y. 1911. Price, $3.25, plus 40 cents postage.

For nine years (1903-1911) the Cornell Nature-Study Leaflets have been a potent factor in developing and maintaining interest in teaching elementary science. These leaflets presented attractive facts regarding selected topics, and presented these facts in a unified story form. Teachers with previous science training found inspiration in the style, form, and method of the leaflets, and those without science training found attractive facts and also inspiration and method. The large demand for these leaflets made it impossible for the publishers to meet all requests. The book now under discussion is based upon the leaflets, and in a more complete way it will meet the needs of those who desired the leaflets, and who often could not secure them.

But the book is more comprehensive than the combined leaflets. An introductory twenty-four page discussion of nature-study teaching is so sane and directly helpful that teachers who read this first part will thereby be able to make good use of the rest of the book. The teacher is expected to use objects, not the book, in teaching children. The book is a rich storehouse of interesting nature facts and stories. It holds more than any one teacher or pupil will observe, but less than *all* will observe. It is a source-book for teacher and often for pupils as well—a source to which both go when observation of objects leaves one stranded, or even when observation of objects temporarily loses interest.

Plant and animal life with a hundred pages given to "Earth and Sky" compose the fields of subject-matter, physical nature-study being omitted.

In the plant and animal life parts, the treatment is based throughout upon selected topics as: "The Chipmunk," "The Common Toad," "The Grasshopper," "How Birds Fly," "The Dandelion," etc.; and the content of the last section may be suggested by such topics as: "How a Brook Drops its Load," and "The Stars of Summer." In each topic there is first given a general account, or "Teacher's Story," then an outline of lesson plans, closing with supplementary reading. Teachers of nature-study or of general science in first-year high school and teachers of biological science in high schools will find in the book much material with which to supplement class, laboratory, field, and text-book work.

O. W. C.

Laboratory Exercises in Physiography, by James H. Smith, Austin High School, Ira W. Stahl, Lane Technical High School, Marion Sykes, Bowen High School, Chicago. D. C. Heath & Co., Boston, New York and Chicago.

"This book of laboratory exercises is designed for either a full-year or a half-year course in the high school." The immediate occasion for its production was the change in the thirty-weeks' course in physiography in the Chicago high schools to a half-year course. This is the third or fourth book that has come out of the experience of the Chicago high school teachers as the course in physiography has passed through the different stages of its evolution and it represents the latest stage of this evolution. The authors have selected forty-five exercises distributed as follows:

Physical experiments, 1; insolation, temperature distribution and range, 4; barometer, 1; winds and currents, 3; weather, 3; rainfall and humidity, 3; relation of rainfall to vegetation, 1; latitude, longitude, and time, 2; rocks and minerals, 2; delta table experiments, 1; map study, 11; farm and mine products, 4; regional geography, 5; field trips, 4.

With each of these exercises great care has been taken, first that the exercise itself shall not be beyond the grasp of the first-year high school student and second that the language in the printed directions and questions shall be clear and comprehensible to the young people using them. With the exercises there are references to several of the modern text-books in physiography. Many of the exercises are divided into an elementary part and a more advanced part, which should make them adaptable to the brighter and duller student or to the longer or shorter course. In the book there are a number of outline maps, maps showing the isothermal lines for January and July, the winds and ocean currents, rainfall, vegetation belts, iron and coal, wheat, corn, and cotton production, the physiographic districts of the United States and the glaciated area of North America.

C. E. P.

High School Geography, by Charles R. Dryer, Professor of Geography, Indiana State Normal School. American Book Company.

This is the first high school geography to be published in America and the first response of the publishers to the agitation for greater emphasis on the human side in the high school physiography courses. The book is divided into three parts. Parts I and II are at hand and part III, which is yet to come will be devoted, it is understood, to regional geography. The three parts will receive a more extended review when the third part is received. Instructors in physiography are already acquainted with the merits of Dryer's "Lessons in Physical Geography" and will welcome with pleasure this addition to the facilities for high school work.

C. E. P.

A Text-book of Inorganic Chemistry, by Dr. A. F. Holleman. Issued in English in coöperation with H. C. Cooper. Pp. 505. Fourth English edition, revised. John Wiley & Sons. 1912. Price, $2.50.

This edition represents a thorough revision by the Dutch author and the American translator. Very many of the chapters have been rewritten bringing the book strictly up-to-date.

The chapter on the following topics are especially valuable:

Radio-active elements, rare gases of the air, colloids, decomposition of molecules and atoms, electrolytic processes, ionic equilibrium, and chemical affinity, enzyme action, syntheses of physiological compounds and the stereochemistry of the sugars.

It is a very readable book, and should be in the library of every chemistry teacher who wishes to keep in touch with the latest theories and discoveries.

C. M. T.

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SCIENCE AND MATHEMATICS SOCIETIES.

Under this heading are published in the February, June, and October issues of this journal the name and officers of such societies as furnish us this information. We ask members to keep us informed as to any change in the officiary of their society. Names are dropped when they become a year old.

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